THE

ELECTRICAL REVIEW

LONDON: PUBLISHING OFFICE, [illegible] Madame Veuve J. Boyveau, Librairie Etrangère, 22, Rue de la Banque. [illegible]

JOHNSON & PHILLIPS,
ENGINEERS AND ELECTRICIANS.

OFFICES—14, UNION COURT, OLD BROAD STREET, LONDON, E.C. WORKS—CHARLTON, KENT.

TELEGRAPHIC ADDRESS—"JUNO," LONDON.

UNITED EXCHANGE TELEPHONE No. 1010. PRIVATE WIRE, CITY OFFICES TO WORKS.

Manufacturers of all Telegraph Appliances, Materials, and Machinery for Making, Laying and Maintaining Submarine Cables, and Contractors for Underground and Aerial Telegraphs.

Sole Makers of Trott & Hamilton's Patent Grapnel Rope and Trott & Kingsford's Patent Indicating Grapnels.

Iron and Steel Telegraph Buoys, Grapnels, both Patent and Ordinary; Centipedes, Creepers, Mushrooms, Sinkers, Cable Tanks, Picking-up and Paying-out Machinery, Dynamometers, Bow and Stern Gear, Steam and Hand Hauling Gears, Rope and Chain Fittings, Cable Drums, Splicing and Jointing Tools, &c., &c.

Machinery Designed and Constructed for the Complete Equipment of Telegraph Cable Factories and Vessels. Steam and Hand Wire Sounding Machines for Deep and Shallow Water.

All Apparatus and Material used in the Construction, Maintenance, and Working of LAND LINES, viz.:—

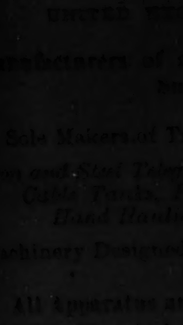
POLES—Wrought Iron or Composite Poles for Telegraph, Telephone, and Electric Light purposes. House-top Poles and Fittings.
INSULATORS—*Johnson & Phillips'* Patent Fluid Insulators, and all kinds of the ordinary form in Porcelain and Brown Ware.
WIRE—Iron and Steel Wire, Galvanized, Plain, or Stranded. Insulated Wires of every description.
BATTERIES—Sole Makers of *Higgins'* Patent Bichromate Batteries, Leclanché, &c. Zinc and Carbon Plates.
INSTRUMENTS.—Morse, Needle, Bells, Galvanometers, and other Testing Instruments.

Makers of Underground, Aerial, Torpedo, and Field Cables, with Single or Multiple Cores.

Insulated Copper Wires in Vulcanized India-rubber, G.P., Silk and Cotton; taped or braided.

Lightning Conductors of the most approved types.

Makers of Dynamos, Lamps, Cables, Carbons, Switches, &c., &c. { ELECTRIC LIGHTING. } Stock of Carbons, &c., kept ready for immediate delivery.



SOLE MAKERS OF THE

BROCKIE-PELL ARC LAMP,

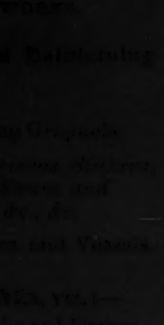
WHICH IS

ABSOLUTELY STEADY

AND

UNEQUALLED FOR INDOOR OR STREET LIGHTING.

ACTION PERFECT IN SERIES OR PARALLEL.



As supplied to H.M.'s Government, New South Wales Government, Leeds Corporation, several Telegraph, Railway, Dock, and other Public Companies, Theatres, Factories, &c., &c., &c.

ESTIMATES GIVEN FOR COMPLETE ELECTRIC LIGHT INSTALLATIONS.

PATENT ROLLED
SHAFTING
IN IRON AND STEEL.

By Royal Letters Patent.

The Kirkstall Forge Company, Leeds,
SOLE MAKERS.

BUTLER'S PATENT FRICTIONAL COUPLINGS.

SILVER MEDAL, INTERNATIONAL ELECTRIC EXHIBITION, 1882.
International Inventions Exhibition, 1885, GOLD MEDAL for Machinery, SILVER MEDAL for Cables and Wire.

MANUFACTURERS by Patent Process of Silk and Cotton Covered Wires and Tapes of all Sizes for Electrical purposes.

Specially Insulated Electric Light Leads, Cables and Flexible Wire for the various Systems.

ELECTRIC LIGHTING

MANUFACTURERS by Patent Process of Fancy Silk Covered and Cotton Wires for Long Connecting, &c.

Special Conductor Electric Light Cables for Main work.

All classes of Aerial and Underground Cables to any Specification.

Special Anti-Induction Cables for the Telephone.

Contractors to H.M. Postmaster-General, the Indian Government, the principal Railway, Telephone, and Electric Light Companies.

MANUFACTURERS, BY PATENT PROCESSES, OF
GLOVER'S PATENT COVERED IRON WIRE FOR AËRIAL LINES.
Glover's Patent Covered High-Conductivity Copper Wire for Aërial Lines.
GLOVER'S PATENT COVERED GUTTA PERCHA WIRE
FOR LEADING-IN, TUNNEL, AND UNDERGROUND WORK.
Thoroughly Insulated Anti-Induction Telephone Cables up to ONE HUNDRED Wires.

WALTER T. GLOVER & CO.,
Electrical Wire and Cable Makers,

TELEGRAM ADDRESS: "WALTER GLOVER, SALFORD." | SALFORD, MANCHESTER. | ESTABLISHED 1868.

WORKS:— Bridgewater Street Iron Works. Salford Electric Wire Works. Springfield Lane Cable Works. SALFORD.

ELECTRICAL PATENTS.—A SPECIALITY.
FELL AND WILDING, PATENT AGENTS,
(J. C. FELL, Fel. Inst. P.A., M.I.M.E., &c., Lecturer on Electrical Engineering at the City of London College, &c., S. P. WILDING, M.S.Chem.I., M.S.A.)
Best technical, legal, and scientific advice in all matters connected with patents. Reliable agents in all countries. Searches made, patent cases conducted, opinions, technical evidence, &c. Trade marks and designs registered.
1 QUEEN VICTORIA STREET, LONDON, E.C.

ELECTRIC WIRES & CABLES

THE UNITED ELECTRIC WIRE CO.,
14a, CLERKENWELL GREEN, LONDON, E.C.

India Rubber, Gutta Percha, Silk and Cotton Covered Wires, Flexible Cords, &c., &c. German Silver Wire for high resistances. All sizes kept in stock. Fancy Cotton Covered Wires for House Bell Work always in stock. Incandescent Lamp Leads and Mains, and Fancy Braided Cords. Multiple Cables for every description of Electrical Work. Gutta Percha Wires, Taped, Tarred and Sanded, and specially prepared India Rubber Covered Leads for Electric Lighting purposes.

PRICE LISTS AND SAMPLE CARDS ON APPLICATION. Registered Telegraphic Address: "UNITED, LONDON."

THE TELEGRAPHIC JOURNAL AND

Electrical Review.

VOL. XIX.—No. 472.

HARVARD COLLEGE
DEC 21 1886
LIBRARY.

IS ELECTRIC LIGHTING RELIABLE?

NEARLY six years have passed since, on the strength of the various patents issued for the subdivision of the electric current for purposes of illumination, it was claimed for incandescent lighting that it was a commercial practicability; and a still longer period has, of course, elapsed since arc lamps first entered the field as competitors with gas. Circumstances prompt us at this moment to glance around and try to gain an idea of the progress made in the interval. That far too much hastiness was displayed in the beginning in endeavouring to work as a perfected invention what was obviously immature, is a truism which it is becoming almost a weariness to reiterate. The present difficulty is that there are many people who still hold the opinion that the electric light in any form is a means of illumination upon which, even after making due allowance for the liability of derangement in the previously known machinery which is combined with the more peculiarly electrical contrivances in its production, it is impossible to depend. In support of this statement we will quote the views of a journal which we suppose may be fairly taken as a representative of opinion in the financial world. *Money* recently said: " . . . . they must show that such immense strides have been made in electrical science that they can perform with punctuality, certainty and efficiency, the contracts they would profess to be willing to enter into. Up to this hour no such assurance can be given by any scientific man who values his position," and so on. This, of course, is absurd. Our survey may be unsatisfactory in some respects in view of the lapse of time since electric lighting made its first pretensions, but it shows us that installations are numerous in every part of this country which are standing evidences of the fallacy of our contemporary's sweeping assertion.

Still there is a shadow of fact which gives rise to impressions of the kind we have instanced amongst the unskilled public, and all who desire to see the electric light and its votaries occupying the position they deserve will agree with us in saying that the sooner the grounds of objection which at present undoubtedly exist are cleared away, the sooner will ambition in this respect be gratified. There are powerful reasons, we know, for the simplification of the means of producing the electric light and the reduction to the lowest possible point of the prime cost of an installation. But when it is recognised that these are factors which have a tendency to operate in two directions, and in a direction which is disadvantageous more rapidly than in one which is favourable, it will be seen that extreme cautiousness must be observed in adopting such modes of cutting down estimates. To those who have not considered the subject it may seem strange that we should counsel the opposite course of increasing the first outlay rather than reducing it. But in justice to the position we seek to fill, and in consonance with the duties which appertain to that position, we must insist upon one elemental fact. The reliability of electric lighting should be placed beyond suspicion, and the one only way in which that can at present be accomplished is by the aid of the accumulator. The deplorable incidents which have recently occurred at the British Museum are but too sure an indication of what may possibly occur in many other places where the lighting depends entirely upon the sustained action of machinery in motion. It is utterly false to say, as does the financial paper to which we have already referred, that such occurrences are happening daily and hourly; but it is a fact that the liability exists. It would not be a matter of very great surprise to us to hear at any moment that the machinery at Paddington Station or that at the Grosvenor Gallery had broken down, and that every lamp supplied from these sources had subsided into darkness. The persons responsible for these and other public or semi-public installations will, if they are wise, at once take warning and see to it that the failure of any one portion of their engineering arrangements shall no longer involve the collapse of the whole of the lighting; although in the cases we have cited, of course, accumulators cannot be introduced. We do not overlook the precautions against failure occasionally observed by the duplication of plant. But we cannot see that this method, expensive as it is, is certain to prevent the lamps from going out and the occurrence of a period of darkness which, however short, must cause great confusion, inconvenience and danger. As a rule, when everything has been going smoothly for some time, the reserve plant is not in readiness when it is suddenly wanted. If there was the constant expectation of a breakdown, every man, of course, would be at his post and the mechanical appliances in perfect readiness for immediate use. But such a state of apprehension, fortunately, does not commonly prevail.

Electrical engineers are rapidly becoming alive to the fact we are trying to demonstrate, and perhaps the wonder is that there are any remaining who do not fully recognise the importance of the secondary battery as an aid to the dynamo in electric lighting. We were quite prepared for the statement which Mr. Reckenzaun made in the REVIEW for November 26th, that secondary batteries to the value of at least £60,000 had been sold in the last twelve months by the two principal firms manufacturing them. Indeed, we believe that the sum is considerably understated, and as the next year's working will certainly show a material extension of the use of accumulators it is evident that the branch of the electrical industry which consists in the manufacture of these useful contrivances is destined to attain vast proportions. The experiences of the last three or four years have done much to remove the objections which were urged to the employment of accumulators, which were at one time regarded by many persons as an additional source of risk, still further complicating apparatus at that time not a whit too reliable. Their character and construction have become better understood, and their value is so indisputable that the engineer who values his reputation hardly dares to refrain from recommending them.

We have adverted to the question of expense, but it should be stated that the full cost of the batteries is not entirely additional. When accumulators are used the generating plant need not be so large as when the lighting is direct, and therefore the capital outlay may be less for that portion of the installation. The commercial side of this matter must always be of great importance, but our space is too limited to deal with it fully here. Possibly our readers may be induced to discuss the subject, in which case our columns will be open to them for the purpose.

The question which it behoves every electrical engineer to consider is, whether the greater certainty of the proper continuance of an installation is not a desirability outweighing the consideration of slightly increased cost. A succession of failures, although of little import to the technical mind, have a decided influence upon popular feeling, and we feel that we cannot too plainly insist that, until some yet more perfect means are devised to surmount the difficulties under discussion, secondary batteries are *absolutely* essential. Of course the fact that it was the engine which broke down at the British Museum, and not part of the purely electrical arrangements, has its full significance as far as electricians are concerned; but it is "the electric light" which is to blame in the public mind. Possibly it would have been otherwise had the engine been situate in the reading room and the lamps in the engine house, but until such an inconvenient mode of arranging an installation is adopted, we must take popular prejudices and inconsistencies into account, and avoid as far as possible arousing them in antagonism to our interests. What we have written has not been with the intention of creating alarm or mistrust, but simply to accentuate the warning which is contained in the breakdown at the British Museum.

Electrical Conductors.—The following appeared in the *English Mechanic* of Friday last. Can any of our readers guess to what it refers? "I shall be obliged if someone will kindly give information as to size of conductors and leakage of electricity in the case stated below. The main conductor would be 25 miles long, supplied with electricity, conducted to it through branch conductors from dynamos driven by turbines of various power, and at various distances—viz., one turbine of 60 H.P. at four miles from the main; one of 40 H.P. at two miles; one of 30 H.P. at one mile; and two of 20 H.P. each at half a mile from the main; total, 170 H.P. given off at the turbines. The main conductor must not be coated with a non-conducting substance, but the branches may be. Required to know:—1. The best material, size, and shape of such a main conductor for supplying the motors of a tramcar or train. 2. Sizes and kind of branch conductors (coated) for conveying electricity from dynamos at the turbines to the main conductor. 3. Loss of power from that given off at the turbines; *a*, through or at the dynamos; *b*, leakage from the branch conductors; and, *c*, leakage from the main conductor (or formula for *a*, *b*, *c*), so that I may calculate the available power at the main conductor. The terms I have used above will probably betray my ignorance in electrical engineering.—ACIER."

TELEPHONE RELAYS.

THE reduction in power which takes place in the articulation from telephone receivers when the latter are worked on a long line subject to considerable leakage naturally suggested the employment of a relay which would enable the current which actuated the receiver to be reinforced. We believe, however, that all attempts to effect what is required has hitherto proved futile. An examination of the conditions under which telephone receivers and transmitters actually work will show that failure must necessarily result; indeed it is somewhat surprising that it could be imagined that success could be achieved. If we compare the conditions under which ordinary telegraph relays and suggested telephone relays have to work, it will be seen that great differences exist. In the case of a telegraph relay, practical experience shows that a very slight pressure of the relay tongue against its contact stop serves to close the current of a battery of practically any required strength, and that the removal of the relay tongue from its contact serves to break this circuit. In fact, the pressure of a grain or two on the relay tongue will close the circuit of a battery sufficiently strong to exert a magnetising force on a magnet equal to a pull on its armature of several pounds, and the removal of this pressure from the relay tongue will open the local circuit and remove the pull on the armature. Now it is obvious that if it were found that the few grains pressure of the tongue of the relay were only capable of closing the circuit of a very weak local battery which should give to a local magnet a magnetic force of a few grains only, then there would be no use whatever in such an arrangement. In other words, so long as the force capable of being brought locally into action does not exceed the original force which brings it into action, then nothing is gained by such a combination. Practical experience has proved most conclusively that the intensity of the tones given out by a telephone receiver joined up on short circuit with a microphonic transmitter can never be made to exceed, or, indeed, to approach, the intensity of the sound spoken against the diaphragm of the transmitter, *no matter what battery power be used.* It follows, therefore, that the power with which the diaphragm of the receiver vibrates must be much less than the power with which the transmitter diaphragm vibrates; in other words, a pressure of say 1 grain against the transmitter diaphragm only causes the receiver diaphragm to be moved with a force of a fraction of a grain, say $\frac{1}{2}$ a grain. If, therefore, this receiver diaphragm be connected to the diaphragm of another transmitter, in other words if a relay be formed, then the force with which the diaphragm of a receiver connected to this transmitter would move, *no matter what the battery power may be*, would be $\frac{1}{4}$ of a grain only; thus the effect of a relay would actually be to reduce, not to increase, the effect. If the variation power of a telephone transmitter were the same with every current strength, then an increase of battery power should produce a proportional increase of effect, but this is known not to be the case in transmitters as at present constructed, and unless some new departure be made it seems certain that any working on the old lines must be mere waste of time.

ON THE TEMPERATURE COEFFICIENT OF CLARK'S STANDARD CELL.

By ARTHUR DEARLOVE, A.S.T.E.

MUCH attention has lately been drawn to the above subject by Lord Rayleigh, who has read before the Royal Society some papers, recently published in the *Transactions*, giving an account of some very interesting and valuable experiments carried out by him during the past and present years.

In January, 1884, and since, I conducted a series of experiments for Messrs. Clark, Forde & Taylor, bearing upon the question of the temperature coefficient of the Clark's cell, the value for which is given by some experimenters as high as ·082 per cent. per 1° C., and by others as low as ·041 per cent. A short account of the results I obtained may perhaps be considered worth publication.

From the nature of the subject, the same ground as that covered by Lord Rayleigh's papers must necessarily be gone over again, but there are one or two fresh points of interest which I do not think have been before noticed.

To determine the variation in E.M.F. of the Clark's cell, due to change of temperature, three cell's were set up and fixed firmly to the bottom of a thin glass jar, which was then placed in a copper vessel, which could be heated or filled with ice at will.

In the glass jar in which the cells were fixed a layer of mercury was put, nearly reaching the top of the cells, in order that they might take up their temperature quickly, and it also afforded a means of getting their actual temperature easily. The top of the jar was stuffed tightly with cotton wool, and when the vessel was heated a mercury gas regulator placed in it, and which acted perfectly, was included in the circuit of the gas supply.

The first observations on these cells were made with the whole of the cells as near 0° C. as they could be got, and then at the various temperatures noted below. The values were actually as follows :—

The standard cell was kept at 0° C. during the whole time.

Ice.	11·11° C.	Calculated value.	22·42° C.	Calculated value.	39·74° C.	Calculated value.
Std.—1·0000						
3.—1·0002	·99255	·99267	·9843	·9842	·96927	·96929
4.—1·0002	·99274	·99278	·9843	·9842	·96869	·96870
6.—1·0003	·99260	·99259	·9841	·9841	·96947	·96947

The expressions calculated for the temperature coefficient of the three cells are :—

3. $1 - 0006157\,t - 000003952\,t^2$.
4. $1 - 0005958\,t - 000004827\,t^2$.
6. $1 - 0006277\,t - 000003538\,t^2$.
Mean of all. $1 - 0006131\,t - 000004105\,t^2$.

In other words, if the E.M.F. at 0° C. is taken as 1, the above formula gives the E.M.F. at any other temperature, t, within the limits of observation.

Transforming the last of the above expressions, *i.e.*, for the mean of the three cells, into the form given by Lord Rayleigh, we have for the temperature coefficient

$$0{\cdot}98988\left\{1 - {\cdot}00074377\,(t-15) - {\cdot}000004147\,(t-15)^2\right\}$$

Taking the E.M.F. of the Clark's cells at 15° C. as 1·454 B. A. volts, the E.M.F. at any other temperature by the foregoing expression is

$$E = 1{\cdot}454\left\{1 - {\cdot}00074377\,(t-15) - {\cdot}000004147\,(t-15)^2\right\}$$

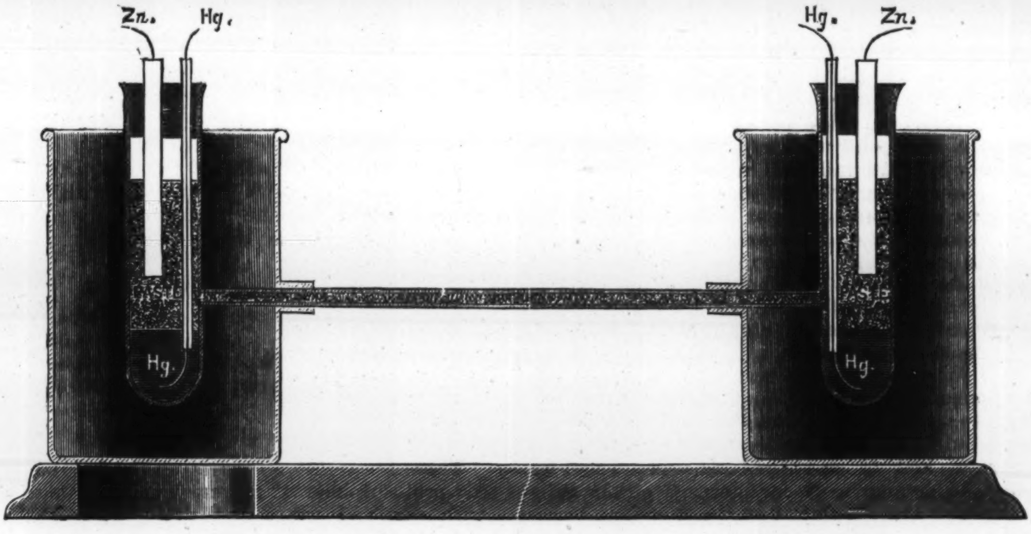
or as a close approximation for small changes of temperature, a simpler form similar to that given by Lord Rayleigh*

$$E = 1{\cdot}454\left\{1 - {\cdot}00075\,(t-15)\right\}$$

may be used.

A comparison of the cells used was made some two days afterwards, and no appreciable alteration appeared to have occurred in their relative values.

The standard being = 1·0000
3 = ·9999
4 = ·9999
6 = 1·0001



B. FIG. 1. A.

The values are practically identical, and agree with what Lord Rayleigh has found in his experiments, viz., that when heated up to 40° C. or 60° C. on cooling down no *permanent* change takes place in the E.M.F.

On concluding the above experiment an attempt was made to, if possible, find what may be called "the seat of the variation of the E.M.F.," and a cell was constructed with this view.

It consisted, as shown in fig. 1, of two vertical glass tubes open at top and closed below; these were connected together at about 1½ inches from the bottom by a horizontal tube a foot or so in length, so that the two vertical tubes could be put in independent outer vessels of copper and kept at different temperatures.

In each vertical tube were the elements of a Clark's cell, viz., zinc, zinc sulphate (in the form of saturated solution), sulphate of mercury and mercury; the horizontal tube was filled with the paste of mercury sulphate and saturated solution of zinc sulphate, contact was made with the mercury by a platinum wire sealed in a thin glass tube and fixed inside the upright tubes.

When the two vertical tubes and the horizontal tube were at the temperature of melting ice the E.M.F. between the Zn and Hg in A was exactly equal to that

---

* Lord Rayleigh's formula for mean value near 15° C. is

$$1{\cdot}454\left\{1 - {\cdot}00077\,(t-15)\right\}\ \text{B. A. volts}$$

between the Zn and Hg in B, and therefore, of course, identical with the E.M.F. between the Zn in tube A and the Hg in tube B, or *vice versâ*.

Now, if one of the vertical tubes, say A, be kept at the temperature of ice, and the temperature of B be raised, the E.M.F. between the Zn and Hg in the heated cell, B, will be less than that of the cell at 0° C., and by this means a comparison between the two at the various temperatures of B could be easily and conveniently made.

A series of observations was then taken upon the four combinations, which are:—

1.—Zn (A) Hg (A)
2.—Zn (B) Hg B
3.—Zn (A) Hg B
4.—Zn (B) Hg (A)

the results of which are embodied in the following table.

It is understood that A is throughout kept at 0° C., and was so situated that it could not be affected by the heat applied to the cell B.

	Ice.	A at 0° C. B at 10·7°	A at 0° C. B at 19·5° C.	A at 0° C. B at 27·2° C.	A at 0° C. B at 34° C.
Zn (A) Hg (A)	1·0000	1·0000	1·0000	1·0000	1·0000
Zn (B) Hg (B)	1·0000	·9938	·9876	·9823	·9771
Zn (A) Hg (B)	1·0000	1·0008	1·0017	1·0024	1·0029
Zn (B) Hg (A)	1·0000	·9929	·9859	·9800	·9740

From the foregoing table it will be seen that both the elements, zinc and mercury, are affected by a change of temperature, and both in the same direction, so that the observed variation in the E.M.F. of a Clark's cell whose temperature rises or falls is due to the *difference* of the effect on the two elements.

The cold zinc is always positive to the hot zinc and the cold Hg also positive to the hot Hg, but the latter in a less degree, the effect on the mercury of a given change of temperature being about one-eighth of that produced in the zinc by the same change.

A further short experiment bearing upon the same point was made. Two clean and pure rods of zinc were put into separate test tubes three-quarters full of the same saturated solution of sulphate of zinc at a temperature of 12·4° C., and these tubes connected by a siphon; the arrangement for heating either tube was the same as that employed on the H cell, and previously described.

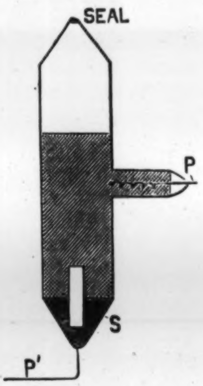
Calling one tube C and the other D, similar tests were made on this combination as on the combined Clark's cells A and B, and the values are now given.

The tube, D, was kept at a constant temperature, and C was heated to the following temperature 10·15° C. and 27°; at a difference of temperature of 10·15° C. the E.M.F. between the two zincs was equal to ·0141 volt, and at a difference of 27° it had increased to ·0283 volt, the cold zinc, D, being positive to the hot zinc, C.

At the temperature of 27° C. crystals of zinc sulphate were added to the hot zinc, C, when the E.M.F. immediately rose to ·0328 volts, or 11·6 per cent. From this fact one would infer that a non-saturated solution of zinc sulphate would make the temperature coefficient of a Clark's cell lower than with a saturated solution. This fact is noticed by Lord Rayleigh in his paper, but, on the other hand, should there be excess of zinc sulphate in any cell the temperature coefficient would appear higher when heated than one whose solution is just saturated, at say the normal temperature of 15° C. It might be more satisfactory to have a standard temperature at which the solution used should be saturated, as then the temperature coefficient of Clark's standard cells would be much more uniform.

In 1881, at Mr. Herbert Taylor's suggestion, several hermetically sealed Clark's cells were made, as shown in fig. 2. In these cells free mercury was dispensed with and an amalgamated spiral of platinum wire was used. This method is somewhat similar to that recently employed by Dr. Muirhead in his new form of Clark's cell; the difficulty met with was that several of the cells cracked—this was due to the manner in which the platinum wire, sealed through the glass and making contact with the zinc, was shielded from the paste. One or two, however, have survived and are still in use, showing no signs of change.

The Clark's cells are quite easily made, and their value and constancy can certainly be depended upon when set up with due care.



P.—Platinum spiral amalgamated.
P'.—Platinum wire making contact with the Zn and shielded from the paste by shellac, S.

FIG. 2.—HERMETICALLY SEALED CELL.

The last batch of cells I set up was on the 18th of December last; six were of the old pattern and four were of the portable form, *i.e.*, with amalgamated platinum spiral. The results are given below; the standard used was the hermetically sealed cell at 13·5° C.

Standard 1·0000 at 13·5° C.

1.— ·9998	Temp. 13·6° C. old form.	7.—1·0001	Temp. 13·6° new form.
2.— ·9999		8.—1·0003	
3.—1·0000		9.—1·0003	
4.—1·0000		10.—1·0001	
5.— ·9998			
6.— ·9997			

These ten cells were set up in the following manner: the protosulphate of mercury was thoroughly washed with distilled water and dried, then the saturated solution of sulphate of zinc added to it, the whole was then boiled for a short time. On the following day the cells were set up with the cold paste.

All comparisons were made by the potentiometer method, using a set of exceptionally well-adjusted "slides" by Messrs. Elliott Bros. A difference in E.M.F. of very much less than 1 in 10,000 was distinctly apparent.

It may be useful to know that cells have been set up with perfectly satisfactory results with paste made a year previously, which in the meantime had been kept in a corked bottle.

It often happens that when exposed to light the paste next the glass becomes dark in colour, due to some chemical reduction. The same occurs in ordinary cells when unprotected from the light, but the layer of paste affected is excessively thin and has not been found to make any alteration in the E.M.F.

It is of advantage when using Clark's cells for accurate work, to have a thermometer enclosed in the cell, and having found by its means the actual temperature coefficient a table of the E.M.F. of the cell at different temperatures is easily made and is very convenient.

The Tilbury Docks.—We understand that Messrs. R. E. Crompton and Co. have supplied batteries on the Howell system to the plant already existing for lighting the Tilbury Docks. We think this a very wise proceeding on the part of the contractors, for we hear excellent accounts of the new accumulators.

ELECTRO-MOTORS AND THEIR GOVERNMENT.

By Profs. W. E. AYRTON and JOHN PERRY.

FOR some time past articles have appeared in the ELECTRICAL REVIEW, and in other periodicals, in which the moral has been drawn that the principle developed by us during 1882, and published at the end of that year, was wrong, this principle being that in a motor the armature ought to be magnetically much more important relatively to the field magnet than it should be in a dynamo. It has further been stated that our differential methods of winding motors to obtain a constant speed, independent of the load, are unnecessary.

The critics considered that they received great support from two experiments made about a year ago, the one which showed that an Edison-Hopkinson dynamo, weighing 46½ cwt., gave, when used as a motor, a commercial efficiency of 92·6 per cent., the other, an experiment carried out by Mr. Mordey, which showed that a shunt dynamo having an armature of very small resistance ran at a fairly constant speed as a motor when a constant potential difference was maintained at its terminals. These two sets of experiments have been regarded as giving the death blow to our principles, but as nobody was able to find out anything wrong in them, the critics resorted to the old fallacy of considering that the principles were right in theory but wrong in practice; forgetting altogether that, if a principle is proved to be wrong experimentally, it must be wrong wholly and utterly.

Either then these experiments proved us wrong or they did not, for being experimenters ourselves we cannot avail ourselves of the mental loophole kindly offered us by the critics that we were quite right—but only on paper. It was not our intention to reply to the criticisms until we had completed certain experiments, the results of which will, we anticipate, place the whole subject beyond doubt, but as we have for some time past been very busy with other experiments, and as it is easy to show, as one of us did at the Royal Society last spring, that while the tests of the Edison-Hopkinson machine proved that it was a very good dynamo they proved that it was a poor motor compared with existing motors, further as it is equally easy to show that the dynamo employed by Mr. Mordey in his experiments would be very unsuitable to be used as a motor in the transmission of power, or when a motor has to be moved about, it may be desirable for us without more delay to state why we hold exactly the opinions we did in 1882 regarding the proper construction of motors, and why we think that the objections that have been urged are without weight.

During the summer of this year a discussion took place in the ELECTRICAL REVIEW between Mr. Mordey and "A Student," and Mr. Mordey came to the conclusion that in 1882 we were not acquainted with the principle underlying the experiments described by him in the *Philosophical Magazine* for January of this year and reprinted in the ELECTRICAL REVIEW for January 8th. We will, therefore, take the opportunity of stating that in 1882 we not only knew, but one of us taught to the students at the Finsbury Technical College that principle, which is as follows: just as a current generator of *constant* E.M.F. and *small* resistance, such as a set of accumulators, a magneto machine or a shunt dynamo with an armature of very low resistance running at a constant speed, will give a constant potential difference at its terminals, so such a magneto machine or shunt dynamo will, when used as a motor, run at a constant speed when a constant potential difference is maintained at its terminals. All the excellent work that Mr. Mordey has done during the last few years has interested us much, but our interest in the particular experiments described by him in this year's January number of the *Philosophical Magazine* arose from our regarding them as proving on a large scale the correctness of the principles that we had taught for some years previously. Indeed "A Student" (whose name we are totally unacquainted with) expressed our views so clearly in the columns of the ELECTRICAL REVIEW this summer that we must thank him for making it unnecessary for us to reply at the time.

But although in 1882 we were fully alive to the behaviour of a magneto machine and a shunt dynamo with a very low resistance armature, we did not then, any more than we do now, regard the employment of such machines as a good commercial method of obtaining a motor that runs at a constant speed. For just as we do not consider that the compounding of dynamos to produce a constant potential difference of, say, 200 volts at its terminals is wholly unnecessary, because a shunt dynamo with a very low resistance armature, either running at a very high speed or with very heavy powerful field magnets, will do the same thing, so in a far less degree do we regard the experiments of Mr. Mordey as showing how to obtain a commercially governed motor. A dynamo of the type used by Mr. Mordey, although very valuable for incandescent lighting, could not, we anticipate, be economically used to propel tramcars, nor electric launches, nor could a small copy of it be used to work portable tools, since we expect that the ratio of its weight in pounds to the useful horse-power given out by it when running as a motor far exceeds 60. Further, such dynamos could not be used as a motor in electric transmission of power, since they required in some experiments 131 ampères to develop 16·3 horse-power, and in others 180 to develop 11·14 horse-power. Let us take the case of 130·8 ampères, and let us assume that the motor gave out about 16·3 horse-power, which is the best result published by Mr. Mordey. Now to transmit 130·8 ampères, calculations show that the most economical section to give to a copper conductor is about one-third of a square inch. But the resistance of one mile of going and one mile of return wire of this sectional area, if made of copper of 98 per cent. conductivity, is 0·1313 legal ohms at 20° C. Hence to send 16·3 horse-power only one mile a waste of 6 horse-power would be produced, which would at once reduce the efficiency of the transmission by 27 per cent.

And, indeed, the fact that the power given out by a motor is roughly proportional to the product of speed into the current passing through the armature into the electromotive force, and that the latter is roughly proportional to the product of speed into the strength of the field magnets showed us, before 1882, that if the armature of a motor has but very few convolutions of wire, either the speed must be high, or the current must be great, or the field magnet must be large in order that the motor must give out much power.

We had, therefore, in 1882 to start with the fact that in spite of a shunt dynamo, with a very low resistance armature, governing when used as a motor, it could not be commercially used as a motor for ordinary purposes, and that therefore its power to govern was of not much practical importance. The question then arose, was there any fundamental difference in the electrical actions of a dynamo and a motor which would lead one to construct a motor on different lines from a dynamo? According to Dr. Frölich there was *not*, for in his paper published on November 18th, 1880, in the "Monatsbericht der Königl. Academie der Wissenschaften zu Berlin" (an abstract of which one of us had made for the *Journal of the Society of Telegraph Engineers*, and which will be found on page 281, Vol. 10), he stated that both in a dynamo and a motor the field created by the current passing round the armature diminished the field due to the field-magnets, and consequently while the Foucault currents induced in the iron of a dynamo armature weakened the field, the reverse occurred in a motor.

We had, however to remember that, while Dr. Frölich was in 1878 publishing the very rough equation that the E.M.F. of a series dynamo was proportional to the current, we saw in the same year that the formula which best fitted the results of the experiments which one of us assisted the late Mr. Schwendler in making on a Gramme and a Siemens dynamo at the India Store Department, London, was (see *Electrician*, page 33, November 20th, 1885)—

$$\text{E} = n\left(e + c\,\text{C} + \frac{a\,\text{C}}{b+\text{C}} + \frac{a''\,\text{C}}{b''+\text{C}}\right)$$

"1.—A small term, e, due to permanent magnetism of magnet, or core, or the earth, or &c.;

"2.—A small term, $c\,\text{C}$, due to current in the wire;

"3.—A term, $\frac{a\,\text{C}}{b+\text{C}}$ due to mag. of electro-magnet;

"4.—A term, $\frac{a''\,\text{C}}{b''+\text{C}}$ due to mag. of core (of armature), which is itself produced by magnetisation of the outer magnet."

When, therefore, Dr. Frölich, at the end of 1880, that is two years later, published, in the communication previously referred to, the formula which has not unnaturally received the name of the "Frölich formula" for the dynamo, but which is simply the formula used by us since 1878, we could not help suspecting that just as he first used a wrong formula for the dynamo, so that now what was new to us about motors in his communication might also be wrong. And we found out that it was wrong and that, while the last term in our expression given above for E was negative in a dynamo, it was positive in a motor. In fact, our whole theory of the construction of motors contained in our patent of June, 1882, is based on the action of a motor being the opposite of that described by Dr. Frölich. This is the more satisfactory because Dr. Frölich has since adopted our view that while the field due to the current round the armature diminishes the field due to the field-magnet in a dynamo, they help one another in a motor (see *Electrotechnische Zeitschrift*, Vol. 4, p. 61 for February, 1883).

It is not necessary to show here how it follows from the resultant magnetic field in a motor being greater than the field due to the field magnet alone that the armature ought to be magnetically more important in a motor than in a dynamo, as this is fully developed in our paper read before the Society of Telegraph Engineers in 1883. We may, however, state, in reply to the criticisms contained in the ELECTRICAL REVIEW for December 3rd, 1886, that we believe that the reason why the motors made in 1883, in accordance with the principles we laid down, were only as good as other motors made at that time, instead of being far better, arose from bad workmanship and from a certain very definite defect in the design, which, having nothing whatever to do with the question of relative sizes of armature and field magnets, need not be entered into here. Their not being now in general use was certainly not due, as the writer in the ELECTRICAL REVIEW for December 3rd imagines, to the use of, or to the necessity for, differential winding, since it was only in the cases where very constant speed was required that we used differential winding at all. We are also quite as certain that it was not due to any defect in the general principle.

It may be said, then, are there then no experiments supporting our theory? We reply, yes; and a comparison between the large Edison-Hopkinson dynamo when used as a motor and a small Immisch motor which was constructed for use only as a motor and not as a dynamo, will bear out the general correctness of our principles of motor construction. We may mention that Mr. Snell, who is Mr. Immisch's right hand, was a pupil of ours at the Finsbury Technical College, was thoroughly imbued with our principles of motor construction, and has made a most praiseworthy and successful application of them. Mr. Snell has assured us many times within the last two years that all his experiments bear out our view that in a series motor the armature ought to be a much more important part of the machine than the armature of a series dynamo of the same total weight. Without going into the details of the Immisch motor, which would be quite beside the point at issue, it is important to remember that the rough rule followed by the constructors is to make a powerful armature, and to put a field magnet outside only just so much larger than the armature as will allow space for the wire to be wound on the field magnet core.

To enable a comparison to be made between the behaviour of the Edison-Hopkinson dynamo weighing $46\frac{1}{2}$ cwt. with an Immisch motor weighing $66\frac{1}{2}$ lbs., it is necessary to see how the power and efficiency of a motor vary with its weight. Such a calculation has been made with greater and greater accuracy by M. Deprez, Dr. Hopkinson and Mr. Kapp, but we think that the following is a still more accurate comparison:—

Comparison of the powers and efficiencies of two motors.—A′ and A, the linear dimensions of A′ being N times those of A, N being greater than unity.

$$\left.\begin{array}{l}\text{If current round field}\\ \quad\text{magnets of A}'\quad\ldots\end{array}\right\} = \left\{\begin{array}{l}\text{N} \times \text{current round field}\\ \quad\text{magnets of A}\end{array}\right.$$

the number of lines of force per unit area with A′ will be the same as with A.

$$\left.\begin{array}{l}\text{The total number of}\\ \quad\text{lines of force passing}\\ \quad\text{through armature of A}'\end{array}\right\} = \left\{\begin{array}{l}\text{N}^2 \times \text{total number of}\\ \quad\text{lines of force through}\\ \quad\text{armature of A.}\end{array}\right.$$

Hence with the same angular velocity

$$\text{E.M.F. of A}' = \text{N}^2 \times \text{E.M.F. of A.}$$

But the angular velocity of the armature of the large machine cannot be as great as that of the armature of the small one.

$$\therefore \quad \text{let angular velocity of A}' = \frac{1}{\sqrt{\text{N}}} \times \text{angular velocity of A,}$$

when the maximum centrifugal force per unit mass in the armatures of the two machines will be equal.

$$\text{Now} \qquad \text{E.M.F. of A}' = \text{N}^{\frac{3}{2}} \times \text{E.M.F. of A.}$$

$$\left.\begin{array}{l}\text{The diameter of wire}\\ \quad\text{on field magnets of}\\ \quad\text{A}'\quad\ldots\quad\ldots\quad\ldots\end{array}\right\} = \left\{\begin{array}{l}\text{N} \times \text{diameter of wire on}\\ \quad\text{field magnets of A;}\end{array}\right.$$

and if the clearance between the armature and the pole pieces in the two motors were made in the ratio of N to 1, the same ratio would hold for the diameters of the wire on the two armatures. But there is no reason why the clearance with the large motor should be N × clearance with the small one.

$$\therefore \left.\begin{array}{l}\text{let the diameter of}\\ \quad\text{wire on armature of}\\ \quad\text{A}'\quad\ldots\quad\ldots\quad\ldots\end{array}\right\} = \left\{\begin{array}{l}\text{N}^{\frac{3}{2}} \times \text{diameter of wire}\\ \quad\text{on armature of A.}\end{array}\right.$$

If, however, the diameter of the wire on the armatures have this ratio, the current with the large motor may be more than N times the current with the small one.

$$\therefore \qquad \text{let current with A}' = \text{N}^2 \times \text{current with A.}$$

The total number of lines of force passing through the armature of A′ will now be more than $\text{N}^2 \times$ the number of lines passing through the armature of A, but how much greater it will be will depend on how nearly the current used with A saturates the iron cores of its field magnets. Since, however, we desire to compare the maximum powers that the two motors can give out without undue heating, we must assume that the current used with A nearly saturates its field magnet cores. In that case

$$\text{E.M.F. of A}' = \text{K} \times \text{N}^{\frac{3}{2}} \times \text{E.M.F. of A}$$

where K is a constant only slightly greater than 1, say 1·1.

$$\text{The power given out by A}' = \text{E.M.F. of A}' \times \text{current used with A}' \text{ approximately.}$$

$$\therefore \quad ,, \quad ,, \quad ,, \quad = 1{\cdot}1\,\text{N}^{3\frac{1}{2}} \times \text{power given out by A.}$$

$$\left.\begin{array}{l}\text{The resistance of field}\\ \quad\text{magnet coils of A}'\quad\ldots\end{array}\right\} = \left\{\frac{1}{\text{N}} \times \begin{array}{l}\text{resistance of field}\\ \quad\text{magnet coils of A.}\end{array}\right.$$

$$\left.\begin{array}{l}\text{The resistance of arma-}\\ \text{ture coils of } A' \quad \ldots\end{array}\right\} = \left\{\begin{array}{l}\frac{1}{N^2} \times \text{resistance of arma-}\\ \text{ture coil of } A.\end{array}\right.$$

$$\therefore \left.\begin{array}{l}\text{The rate of production}\\ \text{of heat in field magnet}\\ \text{coils of } A' \quad \ldots \quad \ldots\end{array}\right\} = \left\{\begin{array}{l}N^3 \times \text{rate of production}\\ \text{of heat in field}\\ \text{magnet coils of } A.\end{array}\right.$$

$$\left.\begin{array}{l}\text{The rate of production}\\ \text{of heat in armature}\\ \text{coil of } A \quad \ldots \quad \ldots\end{array}\right\} = \left\{\begin{array}{l}N^2 \times \text{rate of production}\\ \text{of heat in armature}\\ \text{coil of } A.\end{array}\right.$$

$$\left.\begin{array}{l}\text{The cooling surface of}\\ \text{field magnet coils of } A'\end{array}\right\} = \left\{\begin{array}{l}N^2 \times \text{cooling surface of}\\ \text{field magnet coils of } A.\end{array}\right.$$

$$\left.\begin{array}{l}\text{The cooling surface of}\\ \text{armature coil of } A'\end{array}\right\} \begin{array}{l}\text{Rather more than } N^2 \times \text{cool-}\\ \text{ing surface of armature}\\ \text{coil of } A.\end{array}$$

$$\left.\begin{array}{l}\text{Also the angular velocity}\\ \text{at the periphery of the}\\ \text{armature coil of } A' \quad \ldots\end{array}\right\} = \left\{\begin{array}{l}\sqrt{N} \times \text{angular velocity}\\ \text{at the periphery of}\\ \text{the armature coil of } A.\end{array}\right.$$

Hence the armature of the large motor A′ is, for two reasons, cooler than the armature of A, while the field magnet of A′ is warmer than the field magnet of A. The temperature of the armature, however, is the more important as it is the armature coil that is generally damaged by over-heating. Further, by making the diameter of the wire on the field magnet of A′ rather more than N × the diameter of wire on the field magnet of A, the field magnets of the two motors can be made to have the same temperature without any appreciable change in the total number of lines of force passing through the armature of A′.

$$\therefore \text{The power wasted in } A' = \text{between } N^3 \text{ and } N^2 \text{ times the power wasted in } A,$$

and in order not to give undue advantage to the larger motor A′ let us take $N^{2 \cdot 6}$, so that

$$\left.\begin{array}{l}\text{The power}\\ \text{wasted in}\\ A' \quad \ldots \quad \ldots\end{array}\right\} = N^{2 \cdot 6} \times \text{power wasted in } A,$$

$$\text{and}\left.\begin{array}{l}\text{since}\\ \text{the effi-}\\ \text{ciency of } A'\end{array}\right\} = \frac{\text{power given out by } A'}{\text{power given out by } A' + \text{power wasted in } A'}$$

$$\left.\begin{array}{l}\text{The effi-}\\ \text{ciency of } A'\end{array}\right\} = \frac{1 \cdot 1\, N^{3\frac{1}{2}} \times \text{power given out by } A}{1 \cdot 1\, N^{3\frac{1}{2}} \times \text{pwr. given out by } A + N^{2 \cdot 6} \times \text{pwr. wasted in } A}$$

Experiments show that an Immisch motor weighing 66½ lbs., say 70 lbs., gives 1 horse-power to the absorption dynamometer with an efficiency of 70 per cent. when the motor runs quite cool for a long period. If, then, an Immisch motor were made on the same lines as the small one, but of the same weight as the Edison-Hopkinson dynamo, viz., 46½ cwt., or 5,208 lbs., we should have

$$N = \sqrt[3]{\frac{5208}{70}} = 4 \cdot 206$$

Substituting this value of N in the above expression for the comparison of efficiencies, we find that the efficiency of this large Immisch motor would be 90·4 per cent.

Similarly substituting the value of N in the expression for the power, we find that the actual power that a motor weighing 46½ cwt., but constructed on the lines of the small Immisch motor, would give out, without undue heating, would be 168 horse.

Let us compare this with the actual behaviour of the Edison-Hopkinson dynamo. The highest efficiency reported was 92·6 per cent., not much larger than what our calculation shows that it ought to be, but the power it actually gave out in the trials was only about 48 horse, or *less than one third* of what our calculation shows that an Immisch motor of the same type ought to give. We do not much care whether the right answer for the power of a properly-constructed motor weighing 46½ cwt. when running cool is actually three times, or whether it is only twice the power actually given out by the Edison-Hopkinson dynamo when used as a motor. It is, at any rate, so much larger than the power this motor did give out, that we consider it conclusively proved that a good dynamo is a powerless motor for its weight.

And if still more evidence be required to prove this result, so well known now to makers of motors, we may mention the following very significant fact. On applying within the last month to one of the largest, and certainly one of the most scientific, firms of *dynamo* makers in England for a *motor* to give off one horse-power, they replied that they could not construct it to weigh less than 200 lbs. with good efficiency. And this, we believe, was because they could not disabuse their minds of the fact that we wanted a *motor* and not a *dynamo* to use as a motor.

Our general principle of constructing motors has been abused, yet an intelligent application of it has led Messrs. Immisch (by also paying attention to all details) to construct what we understand are the most powerful and at the same time the most efficient small motors existing. Our principle of obtaining constant speed by the employment of differential winding has been called superfluous, and yet it was reinvented in France last year by M. Deprez, in America this year by Mr. Sprague, and formed the subject of a very exhaustive series of experiments by Dr. Frölich in Germany during 1885.

REVIEWS.

Lives of the Electricians: Profs. Tyndall, Wheatstone and Morse. First Series. By WILLIAM T. JEANS. London: Whittaker & Co., and G. Bell & Sons.

We have here ably written biographies of three eminent physicists, one still living, and two who have already "joined the majority." The first of this illustrious triad, Tyndall, though he has done much and good work in electricity and magnetism, is probably better known for his studies in light, heat and sound. It would, however, be doing an injustice to the author to suppose that he has presented his hero to our view merely as an electrician, or even as a physicist. Prof. Tyndall is held up to us in his relation to the ideas of his time, in his contacts and friendships with other notabilities, scientific and literary, in his public capacities and in his entire personality. And the tale is told in such a manner as to interest persons who do not in the least profess to be physical specialists.

The author's remarks on the "Celtic genius" cannot be accepted without reservation. We can scarcely affirm that a man born in Ireland is therefore of Celtic blood. To us it appears that the Teutonic genius shines more in science, whilst the Celt inclines more to art, and, above all, to theology. Purely Teutonic countries are not prone to the origination of religious sects; but into this question we cannot here enter.

Tyndall's early life was one of hard struggles and of unceasing industry. He was much impressed by some words uttered by the late George Dawson at a lecture delivered at Halifax in 1845:—"Supposing two men were equal at night, and that one rises at six while the other sleeps till nine, what becomes of the gospel of levelling then?"

When the railway mania came to an end Tyndall, who had worked devotedly and creditably as a surveyor, accepted a post as teacher of physics at Queenswood College, Hampshire, an establishment founded under Socialist auspices. Here he formed the acquaintance of Prof. E. Frankland, and subsequently he became intimate with Prof. Huxley. It must not be supposed that the young savant was favourably impressed with the Socialist scheme. He is quoted as saying, "Schemes like Harmony Hall look admirable upon paper, but inasmuch as they are formed with reference to an ideal humanity, they go to pieces when brought into collision with the real one." In the same connection he speaks with a just contempt of the cramming so prevalent in our day.

We next find both Tyndall and Frankland going to Germany to pursue their studies at the University of Marburg. We read that in those days a man could not easily, in England, get first rate instruction in practical chemistry and physics. Can he even yet? In Germany a young man studies science as something to extend and to make discoveries in; in England he is compelled to study it, if at all, as something to be examined in! And this one point mars our entire higher education. In Germany Tyndall studied under Bunsen and made the acquaintance of Ehrenberg, Riess, Du Bois Reymond, Magnus, Clausius, Wiedemann, Humboldt and Helmholtz.

In 1853 he was elected, on Faraday's recommendation, Professor of Natural Philosophy at the Royal Institution, and in 1855 he was also appointed Examiner under the Council for Military Education.

Among his next labours were researches on cleavage and on the movements of glaciers. During the ten years from 1859 to 1869 researches on radiant heat in its relations to the gaseous form of matter occupied his continual attention. He examined the chemical action of light upon vapours, and the action of heat of high refrangibility as an explorer of the molecular condition of matter. The presence of suspended matter in the air led him into a new subject—the question of spontaneous generation. His famous lecture on "Dust and Disease" was delivered at the Royal Institution on January 21st, 1870. It gave rise to the caustic comment that Tyndall posed as a physician, and a certain friend of his as a metaphysician. Prof. Bloxam is described as having said that the germs of malignant disease might be used in war. Are we sure that the attempt will not be made? The question of spontaneous generation and the germ theory brought Prof. Tyndall into friendly relations with Pasteur. In 1869 his celebrated respirator for the protection of firemen against dense smoke was completed and brought successfully into practical use. In 1873 began his researches into the properties of the atmosphere as a vehicle of sound, and on the mutual relations of sound and heat.

The author gives a very full account of Tyndall's adventures and exploits in the Alps. Such performances in so threadbare a country as Switzerland are time thrown away. The same amount of hardship in the Himalayas could not fail to have yielded results much more valuable to his country and to science. The same chapter describes his American tour where he munificiently bestowed the profits of his lectures, about £3,000, towards a fund for the promotion of original research and where he gave his hosts this invaluable advice: "Keep your sympathetic eye upon the originator of knowledge. Give him the freedom necessary for his researches; above all things avoiding that question which ignorance so often addresses to genius—What is the use of your work?"

The year 1874 is marked by his presidency of the British Association, and by his memorable "Belfast Address," the echos of which have scarcely yet ceased rumbling. Strange that whilst on the one hand Professor Tyndall was the denounced of all denouncers, from Cardinal Cullen to Dr. Cumming, from Professor Blackie to Dean Cowie and Bishop Magee (all Celts, be it duly noted!), clericals of all creeds, friars of all orders, white, black and grey being arrayed against the venturesome speaker, yet on the other hand the accredited organ of Agnosticism refers him to the "genus humbug."

Tyndall's connection with Thomas Carlyle is a curious feature in his career. It has been said that in seeking the society of one so unfriendly to science Tyndall, to use an Irishism "turned his back upon himself." He, indeed, attempts to defend the "sage of Chelsea" from the charge of anti-scientific tendencies. But unless Carlyle's own published utterances and the statements of his literary friends, especially Froude, belie him he must have appeared to Tyndall in a deceptive light—"the light that never was on sea or shore." Carlyle is here said to have "approved cordially" of works in which evolutionary principles were advocated "while a personal interview with the great naturalist caused him to say afterwards that Charles Darwin was a most charming man." According to the version which has reached us Carlyle's remark was: "A good sort of man, this Darwin, but with little intellect!"

In 1876 Tyndall married Lady Louisa Charlotte Hamilton. With reference to this marriage Professor Zoellner, of Leipsic, in a polemical work, indulged in an outburst of utterly irrelevant personalities, extended even to the family of the bride. All this was because Tyndall had expressed the opinion that any interference with physiological experimentation would be a great injury to science.

Though Tyndall never, like certain of his early friends became a "bureaucratic savant," or an attaché of the Science and Art Department, he held the post of scientific adviser to Trinity House. His independence of character and his determination to shield an able and meritorious inventor from professional jealousy and red-tape irritation led to his resignation.

Among Tyndall's published works his "Researches on diamagnetism and magneto-crystallic action," his "Heat considered as a mode of motion," his "Lectures on sound," and "Lectures on light," have earned a well-deserved celebrity.

(*To be continued.*)

Theory of Magnetic Measurements; with an Appendix on the Method of Least Squares. By F. E. NIPHER, A.M., Professor of Physics in Washington University, President of the St. Louis Academy of Science. New York: D. Van Nostrand. London: Trübner & Co.

The publication of this book will, we believe, be welcomed by many, as it is the only work of the kind that has been published. Such information as has hitherto existed on the subject has been scattered about in cyclopædias, semi-mathematical works and proceedings of societies, and the student who has required information has been at a loss where to seek for it. In Mr. Nipher's production, information relating to the practical details of a magnetic survey is given, and although the work suffers to some extent from a lack of illustrations of details of instruments, yet the letterpress is generally so well written that the non-existence of these does not to any very great extent detract from the value of the book. The author has given very frequent numerical examples, a practice which is most commendable. The principal parts of which the book consists are as follows:—"Introduction," "Declination," "Determination of Scale Value of the Magnet," "Determination of the Magnetic Axis," "Inclination," "Pendulum Vibrations," "Moment of Inertia," "Moment of Inertia of the Magnet," "Correction of the Oscillation Series for Torsion," "Temperature Correction for Magnetic Moment," "Reduction of the Time Oscillation to that of an Infinitely Small Arc," "Deflection Series of Intensity," "Determination of the Temperature Coefficient q," "Systems of Units," "Appendix on the Method of Least Squares."

THE BRITISH ASSOCIATION.

PROF. BOUTY ON ELECTROLYTIC CONDUCTIVITY.*

(*Section A.—Mathematical and Physical Science.*)

Tuesday, September 7th.

THE author first describes Lippmann's method of measuring the resistance of electrolytes, viz., by tapping off and measuring the E.M.F. between two points of the liquid contained in a cylindrical tube, and comparing this with the E.M.F. tapped off a length of known wire included in the same battery circuit as the liquid. He proceeds to use it also for determining the polarisation of either electrode, by measuring the E.M.F. between one of the main electrodes supplying current to the liquid and one of the tapping electrodes; using the obvious relation

---

* Abstract by Oliver Lodge, made for the British Association Committee on Electrolysis.

$$e = r\,c + p$$

in order to find p, the polarisation.

With platinum electrodes and acidulated water he thus reckons that with a current of average intensity of about $8 \times {}^{-8}$ ampères per square centimetre, the polarisation of the electrode rises as follows:—

	Polarisation of the cathode is	Polarisation of the anode is
In 5 minutes	·056 volt.	·103 volt.
„ 40 „	·063 „	·166 „
„ 60 „	·065 „	·175 „

He then applies a slightly stronger current, but as it is very variable I do not see that the numerical results obtained are much good. However, the idea is that the polarisation of the cathode attains a maximum and begins even to diminish, while that of anode goes on increasing.

He then measures the resistance of acid water in a long siphon tube, and considers that it is independent of current intensity, and asserts: "*A liquid has only a single way of conducting electricity, whatever may be going on at the electrodes. The expressions 'metallic conductivity' and 'electrolytic conductivity' ought to disappear from science.*"

ELECTROLYSIS OF MIXTURES.

A number of mixed salts are tried, one of them being always a salt of copper. Results are given for the electrolysis with copper electrodes of a mixture of sulphate of copper and sulphate of zinc, saturated in the cold, and are analysed thus: "For current intensities from 5 to 12 ten-thousands of an ampère per square centimetre the polarisation of the anode is constant and equal to ·0088 volt; but that of the cathode varies enormously. For an intensity 2·9 (ten thousandths of an ampère as before) it is already ·02 volt; it increases slowly with the current and is sensibly constant for the same current when prolonged. But at an intensity 8·6 a new phenomenon is produced; polarisation increases with time, first very slowly, then more and more rapidly, going from ·04 to ·65 volt; at the same time one notices that the metallic and brilliant deposit of pure copper which one had hitherto obtained is displaced by a ruddy and non-adhesive deposit. In proportion as it is produced the polarisation increases, and the deposit overspreads the electrodes with increasing rapidity.

"Finally, augmenting the current still more, the deposit passes gradually from red to black, while polarisation increases in a continuous manner, and for a sufficient current intensity the deposit acquires anew a certain adherence. It is then dark grey, very rich in zinc, and recalls by its aspect deposits of zinc obtained from impure commercial sulphate of zinc.

"*As for the conductivity of the liquid it remains constant all the time, in spite of the variety of electrolytic actions*, to which a study of polarisation and aspect of deposit bear witness. . . . The same *kind* of thing happens with other proportions of $CuSO_4$ and $ZnSO_4$. . . .

"One may further remark that the specific resistance of the liquid passes through a minimum for a certain composition of the mixture; it is then inferior to the resistance of even a saturated solution of one of the salts, and *à fortiori* to that of the same salt diluted down to the strength in which it occurs in the liquor. *So the molecules of two mixed salts take part in the transport of electricity, even when one of the two metals is deposited on the cathode.*"

All the variations of polarisation in the above case are then simply and naturally explained by the fact of exhaustion, in the liquid near cathode, of the salt of the metal being deposited, except in so far as diffusion replenishes it. With strong currents it is therefore plainly necessary for zinc to be deposited as well as copper, and it is equally obvious that this zinc will tend to clear itself off again by local action.

The author then goes on to observe that very similar complications occur even when only one salt is intended to be present. Thus pure $CuSO_4$ almost always contains a trace of acid, and accordingly, in its solution, hydrogen plays much the same part as zinc has done in the above described experiment. For feeble intensities copper alone is deposited, but for stronger currents the deposit is red and contains some oxide [?]. Hydrogenised copper forms with copper, in fact, local couples in which copper is the attacked element. Evolution of heat by local action has been proved by the use of thermometer electrodes.

Even if $CuSO_4$ contained no acid to start with, it would soon get some by electrolysis; for the solution of anode is never exactly equal to deposit on cathode.

In all these cases one may notice that *electrolytic reactions which go on for the most feeble currents absorb always less heat than those which occur with stronger currents.* This extension to mixtures of the beautiful law announced by Berthelot for the case of electrolysis of a single salt is confirmed by a study of particular cases. For instance, the following table sums up the author's observations on a mixture of $\frac{9}{10}$th by volume of a solution of Na_2SO_4, and $\frac{1}{10}$th of a solution of $CuSO_4$, both pure and saturated when cold. The polarisation of anode is so small as to be negligible; the polarisation of cathode is given for various intensities of current in ten-thousandths of an ampère per square centimetre.

Current Intensity.	Polarisation of Cathode in Volts.	
7	·042	Brilliant deposit of copper.
10	·044	
15	·045	
19	·051	
31	·068	
36	·100	
41	·162	
44·7	·298	
45·4	·859	Brown deposit.
77	1·366	
150	1·585	Abundant evolution of hydrogen.

The brown deposit of oxide appears as soon as the polarisation exceeds ·28 volt. The polarisation increases first very rapidly, then slowly, and its limit is very nearly the number (1·428 volt) which corresponds to the decomposition of Na_2SO_4 between copper electrodes. (It is slightly sophisticated by the extra resistance of gas bubbles then given off.) To sum up: first is decomposed $CuSO_4$, which theoretically consumes no energy (the electrodes being copper), then comes in the decomposition of acid water (·28 volt), finally that of sulphate of soda (1·424).

As for the conductivity of the mixture it remains perfectly invariable in spite of the variability of the electrolytic reactions.

M. Bouty then quotes a saying of Wiedemann, that from a mixture of any of the following metals, Zn, Cd, Pt, Cu, Ag, Au, any metal which follows in the list is deposited to the exclusion of any which precedes. This is manifestly in accord with the above law, for the metals are in order of thermal equivalents. But the fact is only true for feeble currents. With strong currents a mixed deposit is obtained.

To sum up: *liquids have, like metals, only one mode of conducting electricity. Also, they have, like metals, only one contact E.M.F. with an electrode of invariable composition.* But the result of electrolysis being to modify both electrode and liquid round it, their contact E.M.F. alters in a variable manner—whence polarisation.

CONTRIBUTION TO OUR KNOWLEDGE OF THE ACTION OF ELECTROLYSIS ON AN ELECTROLYTE (BEHAVIOUR OF JELLY).

By SVANTE ARRHENIUS.[*]

FROM numerous researches of physicists[†] it has been held as proved that resistance to the passage of an electric current undergoes the same variations as the internal friction—*i.e.*, that both increase or decrease simultaneously. This view is based on a considerable number of data regarding the conductivity of salts in aqueous solution. To obtain further knowledge on the subject it was necessary to test the action of solvents other than water. This has been done by C. Stephan,[‡] who investigated the behaviour of alcoholic solutions, and found only an analogy between electric resistance and internal friction, but not complete proportionality; and this has been confirmed by other observers.[§] That proportionality exists, except in some exceptional cases considered by Stephan,[‖] cannot be held. Unfortunately Stephan has only investigated alcoholic solutions containing from 0 to 70 per cent. of alcohol—*i.e.*, those of which the internal friction is greater than that of water. Had he investigated solutions richer in alcohol, he would doubtless have found that an alcoholic solution of a salt has less conductivity as the corresponding more aqueous solution, in spite of the former having less internal friction than the latter. This has been clearly proved by Hittorf's work,[¶] and has been completely confirmed by Lenz's[**] investigations, although Lenz's work was not directed to that point. I subsequently found on conversing with Prof. Ostwald, of Riga, that he, like myself, disbelieved in any connection between internal friction and resistance, and he proposed that I should undertake the investigation of which an account follows. From a paper by H. de Vries[††] it follows further that the rate of diffusion of a solution of salt is nearly independent of internal friction; a result which Graham's experiments clearly indicate. Lastly, Long's* work shows that the rate of diffusion of an aqueous solution of salt is nearly proportional to its conductivity, whence it follows with high probability that the resistance must be nearly independent of internal friction under similar conditions. And should this prove to be true, the whole of our knowledge of the process of electrolysis would be much simplified.

---

[*] Translated from *Kongl. Vetenskaps-Akademiens Förhandlingar*, 1885, No. 6, Stockholm. By Professor W. Ramsay.

[†] Among others G. Wiedemann; a detailed description of the work of others is to be found in his *Electricity*.

[‡] Wiedemann's *Annalen*, 1882, XVII., p. 673.

[§] E. Wiedemann has proved this to be the case with solutions in glycerine (Wiedemann's *Annalen*, 1883, p. 20).

[‖] Stephan's figures do not exhibit this proportionality. The ratio is not a constant one.

[¶] Poggendorff's *Annalen*, 1859, CVI., p. 554.

[**] *Mém. Acad. Imp. St. Pétersbourg*, sér. 7, p. 30, No. 9.

[††] Beiblätter, 1885, p. 160.

The method of investigation was that proposed by Kohlrausch and Nippoldt.†

The resistance vessels were of the same form as those I previously used. The platinised platinum terminals were 15·5 mm. apart, the diameter of each was 25·6 mm., and through each passed a glass tube 9 mm. in diameter. The solutions investigated were solutions of sodium chloride, zinc sulphate, and copper acetate, in pure water, and also in water in which had been dissolved 4·2 per cont. of commercial gelatine.

The proportions taken were: (*a*) 20 cc. of the salt solution diluted to 25 cc. with water; (*b*) 20 cc. of solution, in which 1·05 gram. gelatine was dissolved, diluted to 25 cc. The gelatine solutions were tolerably fluid at 30°, at 25° very thick and syrupy, at 24° the traces of fluidity were extremely small, and at 23·5° the whole had jellied.

The internal friction was determined by Sprung's‡ method for the gelatine solution containing 4·2 per cent. of gelatine, and was found to be: at 30° C. = 2,271, at 27·7° C. = 2·889, the internal friction of water being taken as unity at 0°. At 24° the internal friction was infinitely great, *i.e.*, the solution had gelatinised and blocked the capillary tube. At corresponding temperatures the internal friction of water is at 30·5°, 0·4475; at 27·7°, 0·4547; and at 24°, 0·5171. The internal friction of the employed weak salt solutions can only have differed but very little from these numbers.

The distilled water showed a resistance of 60,000 ohms, while the gelatine solution averaged 300 ohms. It was therefore considered unnecessary to introduce a correction for the conductivity of the distilled water present. Now, as it is known that all organic substances which do not possess well-marked acid, basic, or salt-like properties have extremely small conductivity, it may be concluded that gelatine also, if free from salts, should manifest great resistance, and the high conductivity of the gelatine is evidently due to the salts which it contains.

The gelatine solution was warmed in a water bath to 35° C. Simultaneous measurements were made of temperature and resistance. As the water cooled the former fell, while the latter slowly rose.

The following table shows in the first column the observed temperatures, and in the second the resistance in British Association units. From these data the conductivity was calculated in arbitrary units (according to the formula $l = \frac{10000}{m}$, m being the resistance given in the second column); the values of l are given in column three. The fourth and fifth columns exhibit the differences of the temperatures and the conductivities.

TABLE I.—CONDUCTIVITY OF GELATINE SOLUTION.

t	m	l	Δt	Δl
14·5°	289·8	34·51		
			2·3	2·03
16·8	273·7	36·54		
			1·0	0·94
17·8	266·8	37·48		
			2·3	2·41
20·1	250·7	39·89		
			1·2	0·99
21·3	244·6	40·88		
			1·0	0·96
22·3	239·0	41·84		
			0·9	10·89
23·2	234·0	42·73		
			0·8	0·96
24·0	228·9	43·69		
			0·9	0·97
24·9	223·9	44·66		
			1·1	1·04
26·0	218·8	45·70		
			1·1	1·10
27·1	213·7	46·80		
			1·1	1·12
28·2	208·7	47·92		
			1·1	1·20
29·3	203·6	49·12		
			1·1	1·26
30·4	198·5	50·38		
			2·2	2·7
32·6	188·4	53·08		
			0·8	1·48
33·4	183·3	54·56		

The results with the gelatine solutions to which salt had been added are given below:—

GELATINE SOLUTION WITH SODIUM CHLORIDE.

t	m	l	Δt	Δl
15·3°	43·6	194·1		
			5·1	23·4
20·4	38·8	217·5		
			4·4	23·6
24·8	35·0	241·1		
			3·4	17·1
28·2	32·6	258·2		
			4·2	22·3
32·4	30·0	280·5		

GELATINE SOLUTION WITH ZINC SULPHATE.

t	m	l	Δt	Δl
14·0°	61·6	128·3		
			3·9	12·4
17·9	56·1	140·7		
			3·8	8·2
21·7	52·5	148·9		
			4·3	16·8
26·0	47·3	165·7		
			4·0	14·3
30·0	43·5	180·0		
			1·5	8·3
31·5	41·7	188·3		

GELATINE SOLUTION WITH COPPER ACETATE.

t	m	l	Δt	Δl
15·0°	62·0	126·3		
			4·1	11·5
19·1	56·6	137·8		
			3·0	9·2
22·1	53·0	147·0		
			3·5	11·8
25·6	49·0	158·8		
			4·4	13·5
30·0	45·0	172·3		
			2·6	12·7
32·6	42·0	185·0		

Here it is evident that the conductivity alters only uniformly with temperature, for had this been otherwise great variations in the neighbourhood of 24° should have been noticeable, for the internal friction increases about that temperature from a moderate value to an infinitely great one. But no sign of such a sudden variation can be deduced from the above figures. The calculated values of the coefficient of temperature for gelatine solution are

Gelatine solution.	Sodium chloride.	Zinc sulphate.	Copper acetate.
0·0281	0·0244	0·0243	0·0248

and for aqueous solutions

	0·0238	0·0234	0·0213

Those for gelatine solutions are generally somewhat higher than for the corresponding aqueous solutions, but the difference is unimportant. It is to be assumed that the coefficient of temperature for internal friction and conductivity is the same for aqueous solutions, this cannot be extended to gelatine solutions, for which the temperature coefficient of internal friction must evidently be infinity (inasmuch as the coefficient of conductivity never exceeds 0·03). If the conductivity of pure aqueous solutions at 17·8°, which are very mobile, be compared with that of gelatine solutions of 4·2 per cent. containing the same amount of salts, which are solid at 24°, the following table results:—

	Sodium chloride.	Zinc sulphate.	Copper acetate.
Aqueous solution ...	250·6	169·6	159·9
Gelatine solution......	205·6	140·3	134·2
Difference...............	17·9 per c.	17·3 per c.	16·1 per c.

The gelatine solution has accordingly about 17 per cent. less conductivity than the corresponding aqueous solution. The found difference of 17 per cent. is not of the magnitude which might be expected if internal friction had really the effect usually attributed to it.

Let us now examine the reasons for assuming parallelism between internal friction and conductivity. In most cases the molecular conductivity in aqueous solutions decreases with increase of concentration, and similarly the fluidity. These relations hold, with few exceptions, for aqueous solutions, and it is therefore not remarkable that the fluidity and the molecular conductivity of aqueous solutions should vary at about the same rate. But it does not follow that they are interdependent or to be ascribed to the same cause. If very dilute solutions be employed the fluidity remains nearly constant, but the molecular conductivity of salts increases considerably with dilution, as I have shown in my former work, and my results have been confirmed by Kohlrausch.[*]

---

* Wiedemann's *Annalen*, IX., p. 623.

† Poggendorff's *Annalen*, CXXXVIII., pp. 280 and 370.

‡ *Ibid.* CLIX., p. 1.

There cannot therefore be a complete parallelism between fluidity and conductivity in aqueous solutions. For very dilute solutions our present views of the nature of electrolysis lead us to conclude that the variations in conductivity are dependent on chemical change, such as the breaking down of complex molecules, the union of molecules of salt with molecules of water, and so on. And the difference between dilute and concentrated solutions is merely a relative one. We cannot draw any definite line between bodies in dilute and in concentrated solution. Thus strong acids in concentrated solution pass through precisely the same phases as weak acids in dilute solution. There is the same relation between alkali salts, on the one hand, and mercury salts on the other. The conclusion follows, therefore, that the molecular conductivity depends chiefly on chemical relations. And there appears no reason to connect internal friction with molecular changes of a chemical nature.

A similar relation holds between the temperature coefficient for fluidity and the conductivity. These are for dilute solutions approximately comparable, and it might be expected that in extremely dilute solutions they should coincide. I have shown[†] that such a relation does not hold either for aqueous or alcoholic solutions. Bouty,[‡] who found complete correspondence between these two quantities, was misled by a coincidence in calculating his results, as Kohlrausch as shown.[§]

As all known cases can therefore be explained without assuming a connection between internal friction and conductivity, this theory, which serves only to complicate matters, must be for the present abandoned.

As a final proof of the justice of the above conclusion I made a cell like an ordinary Daniell, but introduced gelatine into the solutions of zinc sulphate and copper sulphate. The resistance was 1·5 ohm, while that of a similar Daniell's cell was 1·3 ohm. But the resistance of the cell containing gelatine gradually increased after four days, owing to bubbles being deposited in the gelatine near the zinc and the copper.

ELECTRIC LIGHTHOUSES.

At the ordinary meeting of the Institution of Civil Engineers on Tuesday, the 7th of December, Mr. Edward Woods, president, in the chair, the paper read was on "The Electric Lighthouses of Macquarie and of Tino," by Dr. John Hopkinson, F.R.S., M. Inst. C.E.

The author stated that the subject of the use of the electric light in lighthouses had been fully discussed at the institution in 1879, when papers by Sir James Douglass, M. Inst. C.E., and by Mr. James T. Chance, Assoc. Inst. C.E., were read. The subject had been further elaborately examined by Mr. Allard, and more recently in practical experiments, made at the South Foreland, which had been exhaustively reported on by a committee of the Trinity House. The justification of the present communication was that, at the lighthouses of Macquarie and of Tino, the optical apparatus was on a larger scale than has hitherto been used for the electric arc in lighthouses, and presented certain novel features in the details of construction.

At Macquarrie there was a revolving light, giving a single flash of eight seconds' duration every minute. The lamps were of the Serrin type, and were supplied by Baron de Meritens, who also provided two alternate-current dynamo machines, with permanent magnets. Each machine had five rings in its armature, and in each ring there were 16 segments. In supplying one arc for a lighthouse the machine ran about 830 revolutions per minute, and gave a current of 55 ampères when half the coils were used, and of 110 ampères when the whole of the machine was in action, the internal resistance in the two cases being 0·062 and 00·31 ohm. Each machine was driven by an 8 H.P. Crossley gas-engine, through a belt without counter shafting. Whilst the dynamo machines were at the works of Messrs. Chance Brothers and Company, a series of experiments had been made in March, 1881, to determine their properties. When the external resistance was a metallic conductor of small self-induction, it was found that with varying resistance and speed the currents observed agreed fairly well with calculation from the formula

$$\frac{\text{A}}{\sqrt{\text{R}^2 + \left(\frac{2\,\pi\,\gamma}{\text{T}}\right)^2}}$$

in which R was the total resistance of the circuit, γ the self-induction, and T the periodic time. When the machine was running 830 revolutions per minute A = 67 volts and $\left(\frac{2\,\pi\,\gamma}{\text{T}}\right) = 0{\cdot}197$ in ohms squared, hence $\gamma = 6{\cdot}4 \times 10^5$ centimetres. The 80 sections of the machine were arranged four in series, 20 parallel. For a single section the value of γ would be 32×10^5 centimetres. The maximum induction in the core, which had an area of 5 square centimetres, was 24,600, or 4,920 per square centimetre. The loss of power was greater when the machine was doing little or no external work than when that work was great. This was clearly seen from the following table :—

Current ampères	7·70 ...	73·60
Electrical work H.P.	0·69 ...	5·66
Mechanical work applied ...	3·09 ...	6·55
Loss	2·40 ...	0·89

The explanation had been pointed out in the Lecture by the Author on "Some Points in Electric Lighting." Photometric experiments were made upon the arc, and simultaneous measurements of effective power applied and of current passing. The red light was measured through a bright copper ruby glass, and the blue through a solution of sulphate of copper and ammonia. The H.P. was measured by a transmission dynamometer; but the results must be accepted with some reserve, on account of the difficulty of ascertaining the mean tension in a strap which was constantly varying. The oscillations of the dynamometer were damped by a dash pot containing tar.

	Half Power.	Full Power.
Red candles	1,988 ...	4,708
Blue „	4,079 ...	11,382
Current (ampères)	54·5 ...	105
Mechanical power applied (H.P.)	4·5 ...	6·9
Power expended in heating conducting wires (H.P.)	0·24 ...	0·95

The results illustrated the fact that, as the current increased, the total light increased in a higher ratio, red light in a slightly higher ratio, and blue in a ratio considerably higher. The machinery for this lighthouse was sent out to New South Wales in November, 1881. The glare of the light upon the sky was said to have been seen at a distance of over 60 miles, far beyond the distance at which it would cease to be directly visible.

The distinctive character of the Tino light was a triple-flash every half-minute. The apparatus for producing this effect was of the general form introduced by the author in 1874.

As there was no water upon the island, two Brown hot-air engines were supplied, each driving through a counter shaft one of the machines. The counter shafts could be connected by a Mather and Platt friction-coupling, so that the two machines could be driven together, or either machine from either engine. In future light-houses, when a steam-engine could not be employed, it would be preferable on every ground to use gas-engines, and to manufacture on the spot either Dowson gas or ordinary gas, according to the character of the fuel available. There were two dynamo machines of exactly the same type as those supplied for Macquarie, the only novelty being in the method of using them. One of the three lamps was of larger size, for the double-power current of 200 ampères from the two machines when coupled together. This lamp was said to be suitable for a still greater current, but with about 200 ampères it soon became dangerously heated; a simple modification rendered the lamp equal to the actual work it had to do. The apparatus was delivered in November, 1884, and was put up by workmen from Messrs. Chance's workshops, under the supervision of Signor L. Luiggi, of Rome. A complete test of the performance of the light, as seen from the sea in all grades of its power, was made in April, 1885, by a Commission appointed by the Italian Government. The light was well observed through rain when distant 32 nautical miles, and although below the horizon, the position was precisely localised, and the triple-flash distinction unmistakable. At 18 miles distant the illumination of the flash upon white paper was sufficient to make out letters marked in pencil 1¼ inch high, and when 14 miles distant it was easy to ascertain the time from a watch. The light was frequently seen at a distance of 50 miles, near to Genoa. Some general points were dealt with at the end of the paper, and particulars were given of a plan for providing an electric lighthouse at about the same cost as a first-class oil lighthouse.

The following announcement was made :—

Ordinary meeting, Tuesday, December 14th, at 8 p.m.—Discussion upon the Paper by Dr. Hopkinson, F.R.S., M. Inst. C.E., on "The Electric Lighthouses of Macquarie and of Tino."

THE BLACKPOOL TRAMWAY.

The main features of Mr. Holroyd Smith's electrical tramway at Blackpool are already so familiar to the readers of the Review, that it would appear almost unnecessary to refer to any portion of the system again. Still, we incline to the opinion that the figure shown below, reproduced from *La Nature*, gives such a capital idea of the working arrangements between conductor and car that it will be appreciated by the advocates of electric locomotion. Our Parisian contemporary thus describes the illustration, which shows the principal arrangements of the central conductor, of the taking off of the current, of the motor, and of the driving by worm gearing, which constitute the principal parts of the system.

---

[*] *Gôttinger-Nachrichten*, 25th Feb., 1885.

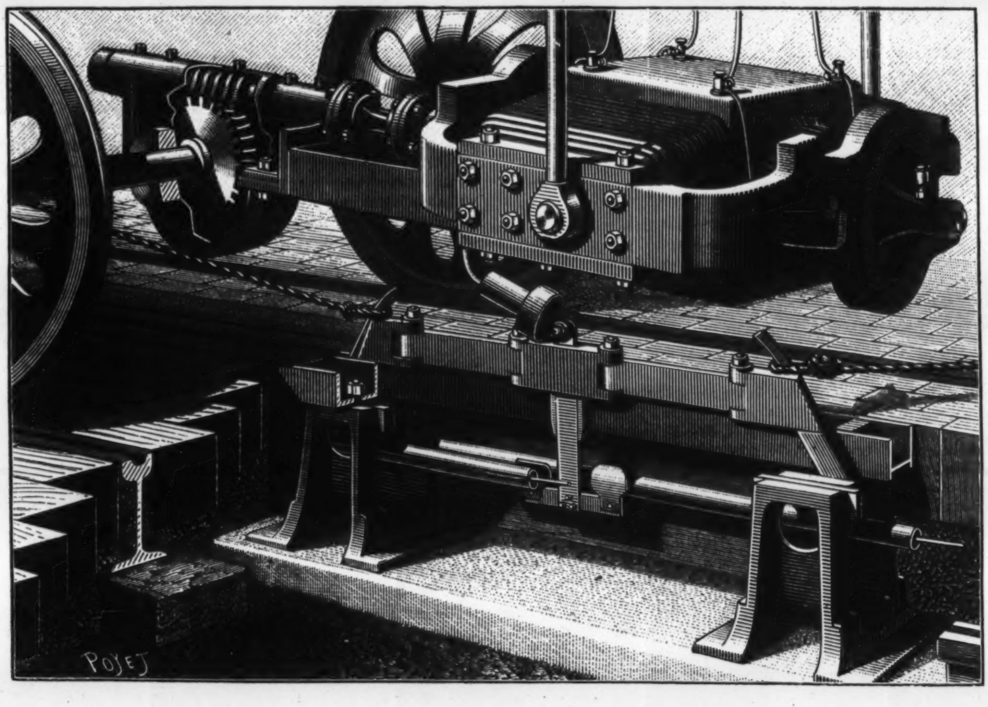
[†] *Bihang t K. V. As Handlo*, 1884, p. 45.

[‡] *Comptes Rendus*, 11*th* Feb. 1884.

[§] *Gött. Nabh.*, 1885, p. 86.

The central conductor is placed in a sort of rectangular trough furnished at the top and sides with wood paving blocks. Cast iron supports are introduced at certain distances apart; porcelain insulators fixed upon these supports serve to carry the conductor formed of two copper strips of semi-tubular shape. It is in the space between these two copper tubes that the collector which takes off the current to the motor slides. The slot formed in the surface of the roadway is narrower than that between the two copper conductors. This arrangement is intended to allow stones, &c., to fall to the bottom of the trough, instead of stopping upon the conductors.

The junctions between the tubes are made by means of brass rods, which exactly fit the hollow of the tube. The collector consists of three parts: one central insulated piece and two clearing rods, placed at each end, which serve at once to guide it in the slot and to prevent twisting. The current is taken up by two shells of bronze, embracing each a portion of the two conducting tubes, and making a permanent contact. The central portion is carefully insulated, and conducts the current to the motor by means of a flexible wire, attached to this central portion by a special detachable coupler, which has the following functions. When the clearing bar only encounters a small obstacle it throws it on one side and continues its course; but when the obstacle is large—as, for example, large bars of iron were fixed in the slot by malevolent persons during the first experiments at Blackpool—the traction rope of the collector is disengaged as well as the electrical communication between the motor and the collector. The collector stops, the car continues to run a short distance by its own momentum, but all breakage is thus avoided. It suffices to take out the obstacle, to reconnect the rope and electrical coupler, and all is again ready for working.



Low Resistance Lamps.—Mr. S. Bottone speaks very highly of Messrs. Shippey Bros.' low resistance incandescent lamp for use with batteries. He knows of only one which is superior, but this does not appear to be in the market.

NOTES.

House to House Lighting.—We hope to be able to chronicle the opening of the central station of the Kensington Court Electric Company within the next two months. The work is going on most satisfactorily and when finished it will be the first station on the direct supply system in the Metropolis.

The Electric Light at Liskeard.—It has been decided not to float a company at Liskeard for the purpose of adopting the electric light, but the Town Council have been recommended to light the town by electricity.

The Electric Light at the Temple Church.—Recently we had an opportunity of noting the effect of the incandescent lamps as placed at this church, and although we have no fault to find with the illumination, which is neither too much nor too little, we regret that advantage has not been taken of the bosses along the centre of the nave to suspend the lamps therefrom. This is a matter probably beyond the province of the electrical contractor, but an elegant and appropriate, instead of an unshapely, effect would have been produced had this been done.

The Maxim-Weston Electric Company.—It is stated that amongst other large contracts which this company has recently secured is one for the lighting of the celebrated San Carlo Theatre, in Naples. The contracts now in hand, the works' manager is credited with asserting, amount in bulk to over 50 tons of plant.

Lighting of a Corn Mill by Electricity.—The Leeds Co-operative Society's corn mill, in Manor Road, has just been lighted by electricity. The installation consists of a Crompton's No. 15 compound self-regulating dynamo machine, capable of driving 450 lights (16 candle-power each), and is fitted with belt driving gear capable of transmitting 45 horse-power. The lamps are Edison and Swan's, but only 220 are at present in use. The lights are divided into four circuits. The installation has been carried out by Mr. Wilson Hartnell, of Leeds, who has made the lighting of corn mills a speciality. The dynamo switch-board, which is for six switches, is of slate and is Hartnell's patent.

The dynamo countershaft is connected with both of the mill engines, so that the light is independent of either. The wires are heavily insulated, and the branches to each lamp are furnished with fusible cut-outs, and the whole arranged so as to be absolutely safe. The lamps are so fixed that any of them can be taken down or replaced by unskilled hands in a few seconds. It is well known that the fine dust or fluff in corn mills is very inflammable when it comes in contact with the gas lights. Knowing this and recollecting that one of their mills was burned down a few years ago, the directors determined, after making exhaustive inquiries, to light the mill by electricity, with the result as above stated. Mr. Hartnell has also just completed the lighting of Messrs. Belben's mill at Poole. This installation consists of upwards of 100 lights distributed throughout the mill buildings. It has been running a few weeks, and continues to give the highest satisfaction.

Electric Lighting at a Bazaar.—At the bazaar of the Exeter Literary Society, opened on Wednesday last week, Messrs. J. W. Lusty and A. de Lisle exhibited an interesting collection of electrical apparatus. Another novel feature was a handsomely-furnished drawing room lighted by electricity. This installation was carried out by Messrs. Shippey Brothers by means of batteries charged in London and conveyed by rail to Exeter, where they served for three days' continuous lighting from 12 noon till 10·30 p.m.

The Telegraph in Italy.—The following table may be of interest as showing the development of the telegraph system in Italy at three periods :—In 1860, when one law (the Piedmontese of 1859), was applied to the whole of Italy ; in 1865, the commencement of a new organisation : and in 1885, representing its present condition :—

	1860.	1865.	1885.
Length of lines (kilometres) ...	7,833	14,792	30,000
„ „ wires „ ...	12,012	37,323	108,000
Number of stations open to the public	248	417	3,000
Number of telegrams	500,000	1,700,000	7,900,000
Receipts, excluding official messages (francs)	1,370,000	4,561,842	10,564,422
Expenditure (francs)	1,936,000	4,751,260	9,680,232
Receipts from paid official messages and value of those sent free (francs)	...	2,318,489	2,311,377

The Berlin Telegraph Service.—The country in Europe in which the electric telegraph was first placed at the disposal of the public was Prussia ; but when this occurred in 1849, the price per message was so high that it was almost prohibitory. Thus, a telegram of 20 words from Berlin to Cologne, which now costs 1s. 3d., cost then 14s. in the daytime and 28s. 6d. at night. First, in 1875, when Dr. von Stephan became Director of Telegraphs, the cheaper tariff was introduced, and with that followed an extended use of the telegraph, which was specially noticeable when the word rate was introduced. In November of last year the largest telegraph station in Germany was opened at Berlin ; the length of the hall is 130 feet, and the width 60 feet. With this hall 267 subterranean telegraph lines are connected, 56 of which belong to the great subterranean lines to Hamburg, Kiel, Strasburg, Mayence, Cologne, Metz, Breslau, and Stettin, whilst 33 overground wires are reserved for the enormous foreign correspondence, and 70, also overground, for the inland service, the remaining being reserved for local communication. The number of operators at this station is 650, supported by 130 assistants, of whom 150—200 are at work during the day, 60—94 during the night hours from 9 p.m. to 2 a.m., and 17 from 2 to 7 a.m. About 20,000 messages are despatched daily. The station is directly connected with 25 chief centres abroad, 584 stations in Germany and 96 in Berlin. The station most distant is Rome, 1,262 miles ; and as this line is connected with the great international lines, communication is thereby also open to India. The local service, too, has been greatly extended during the last 25 years. Thus, for instance, the number of stations, then two, is now 100, irrespective of telephone stations and those of the pneumatic tube service. The latter has greatly eased the telegraph service during recent years ; its central station is at the telegraph head office, whence four main tubes run east, west, north and south. The tubes are 2½ inches wide, and lie 3 feet below the pavement. With a velocity of 1,000 yards per minute little boxes of sheet steel, containing 20 despatches, are sent out. The contents are telegrams, tube-post letters, and post-cards ; whilst 10 or 12 of these boxes form a train. Every quarter of an hour a train is despatched, whereby a message is received in 10 or 15 minutes, at latest, one hour after being posted. The pneumatic tube service, the establishing of which has cost £140,000, possesses now 31 stations, 8 engineering shops, and 360 miles of tubes. During the last two years three million messages have been forwarded.

Telegrams to China.—Telegraphic communication with China, Hong Kong, and Manila by the Great Northern Telegraph Company's route is restored, and the line is again working well.

Conference on the Protection of Submarine Cables.—The third conference on this question held its first séance at the Ministry of Foreign Affairs, Paris, on the first of the current month. Owing to the absence, through illness, of M. Granet, the Minister of Posts and Telegraphs, the conference was opened under the presidency of His Excellency M. de Albareda, the Spanish Ambassador to France. Our readers will remember that the first conference on this subject was held in Paris in 1884, and an International Convention was drawn up and signed on the 14th March of the same year. This convention was to have come into operation on the 15th January of 1886, but was postponed until the 1st January of 1887, owing to the fact that many States had not legislated at all on the subject, and that others, notably Great Britain, had introduced a local legislation whose spirit was diametrically opposed to the decisions arrived at, and the laws agreed to, by the committee. At the conference assembled on the 12th of May of the present year* final legislation on the matter was postponed until the present meeting, for the same reasons that previously delayed the settlement of the questions so long pending. The committee has now to examine into and report on the various laws on cable protection which have come into operation in foreign countries since the last convention. Among the subjects under discussion on the present occasion is the period at which the convention should definitively come into force. To this effect the delegates have been interchanging their views on the matter.

The Conference has adjourned until July 1st, some of the signatory States having not yet adopted the penal legislation which is intended to ensure the execution of Article 12 of the Convention.

Proposed Conference on Cable Subsidies.—Sir Julius Vogel has declined finally to reopen negotiations with regard to the payment of a subsidy for the New Zealand cable. He says the reduction offered by the cable company is very trivial, and that a continuation of the subsidy would only strengthen the monopoly and prevent the construction of a new cable. The Government thinks the whole charge on the cables between the Colonies and Europe should be greatly reduced, and Sir Julius Vogel suggests a conference of the Colonial Postmasters-General in New Zealand.

The Gale and Telegraphic Communication.—In consequence of the gale of Tuesday and Wednesday, the *Times* of Thursday was without its usual batch of late telegrams from its Foreign Correspondents, telegraphic commuuication with the Continent having been severed.

---

* See our issues for May 21st and June 18th, 1886.

The International Cable Company. — Letters of allotment were sent out on Wednesday last, and it therefore seems that the directors have decided to proceed with the work.

The Van Rysselbergh Telephone System.—Steps are now being taken by the Post Office authorities of Berlin, *Industries* states, for the introduction into Germany of Van Rysselbergh's system of simultaneous telegraphy and telephony.

Telephonic Communication in "the Three Towns."—Some statistics have just been published, showing the rapid strides which the telephone exchange has made in Plymouth, Devonport, and Stonehouse. On November 30th last year, there were sixty subscribers connected, and 103 messages were transmitted on that day. Last week the subscribers numbered 138, and in one day no less than 495 messages passed through the exchange. During a week in November, 1885, 628 messages were communicated by telephone ; last week the total was 2,965, the conversations averaging three and a half minutes. It is anticipated that the new year will bring a large increase in the subscribers' roll, and without waiting for the stipulated 200 members, the Western Counties and South Wales Telephone Company contemplates conceding day and night service, which has already been granted to Portsmouth, where there is a smaller exchange.

English and American Telephonic Charges.—According to a recent statement, the charges for telephonic service in this country compare very favourably with those which prevail on the other side of the Atlantic. In New York the annual exchange rate is £31 5s., in Chicago £26, in Philadelphia and Boston £25, and in Baltimore and St. Louis £21. In the United Kingdom the rates are as follows :—London, Liverpool, Glasgow, and Manchester £20, Edinburgh £15, Bristol £15, Sunderland £14, Dublin and Newcastle £12, Plymouth, Bournemouth and Portsmouth only £10 per annum.

The Victorian Government and the Telephone.—The negotiations for the purchase by the Victorian Government of the Melbourne Telephone Exchange Company do not seem to have made much progress for months. The directors of the company have written to the Government with regard to the proposed purchase, stating the position in reply to the Government proposals, on which they suggest that the Government should make an offer, failing the acceptance of which the company is willing to consider a proposal for arbitration.

Edison and Swan v. Woodhouse and Rawson.—Messrs. Mark Baily and Co. inform us that they have withdrawn from the committee of the Electric Light Defence Association, in consequence of a resolution which was passed unanimously in favour of an offer being sent to Messrs. Edison and Swan, asking them to grant a reasonable royalty to the trade and other makers, not having been carried out.

A Ghost.—Mr. Bosanquet, who apparently has a free entreé to the pages of the patriarchal "Phil. Mag.," has discovered a "ghost." The ghost used to visit him mostly in summer between the hours of nine and eleven in the forenoon and about six in the evening. It caused peculiar deflections of his mirror galvanometer, which were sudden and capricious, and frightened him so that he ceased all work for the time. When he recovered his equanimity he traced the ghost as being due to the solar heat falling more or less directly on the instrument and causing hygroscopic changes in the silk fibre. A little infusion of practical experience into this gentleman's laboratory would check these wild theoretical spirits.

American Wire Manufacture.—The wire mills in America, it is stated, are running full, owing to the extended use of wire for electric purposes and fencing.

The Khotinsky Accumulator.—We read in a German exchange that the German Edison Company has had but little success with the Khotinsky accumulators, so little, indeed, that they have been removed from their premises.

A Suggestion.—A friend has suggested that a company formed with the object of letting out accumulators on hire would have a capital chance of success. The first cost of these articles is very great, much more, in fact, than many persons in good positions care to pay, and we think the idea as above suggested might be acted upon with advantage both to supplier and consumer.

Dynamo Testing.—Mr. James Swinburne evidently does not believe in the accuracy of the tests made some time since by the Drs. Hopkinson on two Edison-Hopkinson machines, one acting as generator and the other as motor, for in a recent article he says: "Unfortunately the published tests of Drs. Hopkinson discrepe too much to be of use." His arguments, however, appear to be based on some erroneous figures published, we believe, orginally in an article by Mr. Kapp. No doubt the Drs. Hopkinson can explain the discrepancy which exists between their own figures and the erroneous calculations of Mr. Kapp to the satisfaction of Mr. Swinburne. We believe that the source of error was the mistaken reading of a spring balance.

The Parallel System.—Major-General Webber in his paper on glow lamps says :—"It will readily be appreciated that the word 'parallel' is a misnomer, the parallelism of the conductors having nothing to do with the efficiency." We have hitherto been under the impression that the term "parallel" related to the method of connecting up the lamps between the conductors, and so, we think, has been the innocent belief of everybody else, and even now, in spite of the above quotation, we hold to the opinion that "parallel" is quite justifiable, and that the author of our extract has formed an erroneous notion of the meaning of the term as applied to electric lighting.

Electrical Circuits.—We have in other places alluded to the paper read on Wednesday evening by Major-General Webber. Here is something additional which will perhaps amuse if it does not surprise :—"It would, I conceive, be well if the public, and above all insurance companies (for it is largely a question of fire risk) could be brought to understand that the second or return wire is electrically the same as the 'earth' of the electrician, and that so long as the positive or supply wire is well insulated and kept far apart from the negative or return wire, no further precautions are necessary." We always thought that one electrical property of a wire was resistance, and that to make this resistance electrically the same as the "earth" its value should be nil. As a matter of fact in the parallel system the resistance of the two leads is usually similar, and although one is positive and the other negative their tendency to leakage is the same, and so long as one is intact the defective state of the other is not a matter of consequence, but the insulation of both acts as a double preventive of faults. Continuing the paragraph in question to come to a statement which we could hardly credit as having been made by a gentleman in the author's position, we actually have this astounding assertion, "and when they (the leads) are thus far apart, even if one is bare, greater security is obtained than by the present system, *which unreasoningly insulates the wire which need not be in a state of electrical tension, as well as that which is always ready to discharge*." We wonder whether the author has ever studied the elementary laws of electrical science which relate to the distribution of the electrical tension in a circuit, if he had we could hardly have imagined that he could have been led into such a state of misapprehension ; a circuit through which a current is flowing and which is not in a state of electrical tension would indeed be a novelty.

School of Electrical Engineering and Submarine Telegraphy.—The football club in connection with the above school gave a subscription dance at the Portman Rooms, Baker Street, on Friday evening last. Accompanied by their sisters, cousins, aunts, &c., a large number of past and present students enjoyed a long and well-arranged programme to the strains of Coote and Tinney's excellent band, dancing being continued until an early hour of the following morning. It had been intended to illuminate the rooms by means of electricity; but, unfortunately, the committee had omitted communicating with the companies in whose offices the building is insured, and consequently the idea had to be abandoned.

Glow Lamps.—We must confess to a feeling of intense disappointment on the perusal of Major-General Webber's paper, "Glow lamps: their use and manufacture." It was expected that something would have been forthcoming which had not hitherto been published; but we look in vain for anything novel or even instructive. In the place of this, however, we find expressions used in the paper which are absolutely misleading; but these we deal with elsewhere. We would much rather hear the gallant Major-General deal with the topic in which he must necessarily feel most at home, viz.: Electricity as applied to warfare. We shall, however, publish an abstract in our next for the benefit of those whom it may concern.

Lecture.—A lecture on multiplex telegraphy was delivered by Mr. Eden, of the Engineering Department, Postal Telegraphs, to the Department's employés at Leeds last week. The lecture, which occupied nearly two hours in delivery, was listened to with marked attention, and on the motion of Mr. Tremain, Superintendent at Leeds, upon whose suggestion it had been given, a very cordial vote of thanks was awarded to Mr. Eden.

A Jubilee Tower.—It is proposed to erect somewhere near Trafalgar Square a tower, 420 feet high, to commemorate the jubilee of the Queen's reign. It is to be built by a company and will be used as a view tower, the situation being about the most suitable that can be imagined for seeing London, or the greater part of it, at one time. Ascent will be by means of an hydraulic lift. Sir F. J. Bramwell, F.R.S., has consented to act as consulting engineer during the erection of the tower.

Electro-Motors.—Our readers are well aware of the views held by Mr. Reckenzaun respecting the proper construction of motors. He has stood almost alone in this, but he has now cause to congratulate himself on having so steadfastly and tenaciously kept to the path he believed to be the right one. The arguments advanced by Professors Ayrton and Perry in the paper which we publish on page 563 of this week's REVIEW completely bear out Mr. Reckenzaun's contention, and they will be hard to refute. The reference to the Immisch motor will, no doubt, give the inventor no little satisfaction, and the whole matter forms an extremely fruitful topic for discussion.

An "Electric Bell" Imposter.—The police call the attention of householders to a man who calls at houses where electric bells are used, and says he has been sent by some firm to inspect or repair them. If permission is given to look at the bells he decamps with any property he can lay hold of. His description is—age 23 or 24, height 5 ft. 3 in., complexion fair, small features, Roman nose.

The Brighton Electric Tramway.—Mr. Volk has of late been the victim of the elements to a very great extent. For the second time, within a few weeks, his little tramline on Brighton beach, has been seriously damaged, for we read that on Wednesday it was submerged, and a large number of sleepers carried away, although, fortunately, the rails remained intact.

An Electric Soldering Iron.—A "new" soldering iron has been introduced. It is described as "a kind of Jablochkoff's candle, which is welded so that the blindingly hot flame at its tip is made to melt the surfaces, or the edges of the surfaces which are to be soldered together." The effect is said to be very satisfactory, and the action as good under water as in the air; the heat is so intense and localised within such a small space. This is an idea which has been before worked out and patented by the late Richard Werdermann.

Raising the Price of Gas.—The directors of the Okehampton Gas Company have decided to raise the price of gas supplied to the Town Council from 1½d. to 2d for each lamp per night.

Action Against Mr. Volk.—At the Brighton County Court, last week, before Judge Martineau, an action was brought by Mr. Simmons of Eastern Road, Brighton, on behalf of his son, a minor, to recover damages, viz., £30, from Mr. Volk, of the Brighton Electric Railway, for injuries received through the alleged negligent and illegal driving by a servant of the defendant of an electric tram. The evidence for the plaintiff was to the effect that on September 1st he was riding a bicycle along the Madeira Road, when the tramcar, which was travelling in the opposite direction, frightened a horse attached to a cart which was just passing at the time. Plaintiff was thrown off his machine and severely injured. He was taken to the County Hospital, but not detained. It transpired that a whistle had been blown in the usual way, and his Honour said that he was satisfied that there was no negligence. Plaintiff's solicitor, Mr. Olding, contended that the earth conducted the electricity from the tramcar, and that the horse received a shock; also, that the railway itself was illegal, as it had not been authorised by Act of Parliament. The Town Clerk of Brighton proved that Mr. Volk was liable for any accidents which might occur through the railway. Mr. Volk, himself, afterwards entered the witness-box, and alluding to the suggestion that the horse received a shock, observed that he could not afford to work the electricity all over the road. He had offered the boy £1 towards the machine being repaired, although the accident was not caused by the car, which he incidentally mentioned, had been driven along the Madeira Road 100,000 times (representing 75,000 miles), and had carried about a million of passengers. The case was eventually adjourned.

Electric Locomotion.—The *Electrical World*, in speaking of electric tramcars, says: "We believe ourselves that as regards the point of expense, cars equipped with accumulators can be run at least at two-thirds the cost of cars on cable roads, and there is, moreover, the immense advantage that each car carrying its own power is an independent unit, whilst, as we see so often on the Brooklyn Bridge, the slightest accident to the cable paralyzes the whole service, and generally in the hours when the travel is greatest. Another point of significance and that will have consideration is that individual cars can be taken in hand for change, and thus the existing rolling stock be progressively adapted to the needs of the new conditions. This involves a smaller initial outlay and gives opportunity to train the present force in their new work, which, again, has a recommendation for them in being easy to do and less exhaustive physically."

Welding by Electricity.—Messrs. H. Thame & Co write:—"We notice in your issue of the 3rd that Mr. Radcliffe Ward claims the priority in welding by electricity in the year 1884. We beg to say we have used this method since 1881 for soldering or burning the lead connections on secondary batteries, and prefer it to any other. Doubtless other secondary battery makers have done the same; it makes a clean joint and good contact, and little skill is required in manipulation."

Our Columns.—We have been obliged to hold over several articles through pressure on our space, including that on Secondary Batteries, by Mr. Reckenzaun, and others on the Advances and Improvements in the Application of Electricity to Railway Working.

King's College Engineering Society.—A large assembly gathered on Friday evening last, at King's College, on the occasion of the *conversazione* of the Engineering Society. Some good music was provided, and there was an interesting display of scientific objects in the various rooms. Many of the guests availed themselves of the opportunity of inspecting the college workshops, with their forges, furnaces, machinery, and tools in active use. Several electrical firms had contributed articles of interest on loan, including Messrs. Woodhouse and Rawson, Messrs. Elliott Bros., Mr. Immisch, and others.

Worm Gearing.—It will be noticed that Mr. Holroyd Smith has adopted the worm gearing for his tramcars which Mr. Reckenzaun was the first to employ for the purpose.

Tramway Conductors Extraordinary.—We have just had submitted to our inspection a system of underground conductors for electrical tramways which bid fair to effect quite a revolution in the present methods of conveying the current to the motor. We can only at present say that the conductor is entirely enclosed so as to be quite unaffected by any external influences. There is no central channel, no slots, the contacts, which are not of the rubbing kind, are out of sight and reach, they cannot wear out, and we have no hesitation in saying that it is by far the best thing of the kind which has ever been brought before our notice.

Messrs. Crompton's Works.—The members of the Mechanics' Institute of Chelmsford visited the works of Messrs. R. E. Crompton and Co. last week. The visitors, who numbered about 400, had the various stages of manufacture of dynamos and electric light plant explained to them by the pupils and staff. A search light was in operation and seemed to be very popular. It was placed in the tower on the roof of the works, from which a good view can be obtained of the surrounding neighbourhood, and as it happened to be a clear night, the country was visible for nearly four miles. A short popular lecture was given later on by Mr. Crompton, and afterwards a more detailed explanation by Mr. Swinburne.

The Physical Society.—Errata in report of Physical Society's meeting, November 27th :—

Lines 7, 15, 16	*for*	y	*read*	γ.
Line 24,	„	$c r r$	„	$c p r$.
„ 26,	„	y	„	q.
„ 27,	„	q	„	y.
„ 31,	„	$= \mathrm{M}\frac{d y}{d t}$	„	$- \mathrm{M}\frac{d \gamma}{d t}$.
„ 33 and 35,	„	y	„	γ.

Accumulators.—A good deal of misunderstanding still appears to exist in the minds of many persons more or less connected with electrical pursuits respecting the *modus operandi* of secondary batteries. We would refer those desirous of studying the matter to the series of articles appearing in the REVIEW from the pen of Mr. A. Reckenzaun, also to the pamphlet by Sir David Salomons, to which we alluded in our last.

Electric Telegraph Jubilee Exhibition.—At the weekly meeting of the council of the Balloon Society held in the Royal Aquarium library, Captain Parry, R.N., in the chair, the following resolution was proposed by Mr. Rogers, C.E., seconded by Mr. Merritt, and carried unanimously :—"That an electric jubilee exhibition should be held to celebrate the invention of telegraphy in 1837."

The New Submarine Torpedo Boat.—The electrical machinery for the torpedo boat described by us last week was designed as well as supplied by Messrs. Lewis Olrick & Co.

Killed by Electricity.—A curious instance of death by electricity occurred recently at Moscow. A *fête* was given at a public pleasure resort, enclosed by a wooden palisade, the exterior of which was illuminated by the electric light, when some peasants attempted to gain an entrance by breaking through. The foremost had already succeeded in getting his head and arm through the opening in the palisade when he expired without uttering a sound. The unfortunate fellow had grasped one of the electric wires, and death was instantaneous.

The New Stone Buildings.—We hear that these buildings, which are situated in Chancery Lane, are being electrically lighted under the auspices of the architect, Mr. Thos Clark.

Information Wanted.—We should be glad to learn whether there is any truth in the rumour that a considerable fire was originated some time since at Paddington in the electric light department.

American Patents.—Professor Silvanus Thompson did well to attract attention in our last issue to the very queer practice of the American Patent Office. We cannot recall a more glaring instance of official incompetence than that of refusing to Mr. Bernstein what was afterwards granted to Messrs. Gaulard and Gibbs. We hope, however, that this matter will be officially investigated, for such conduct should not be allowed to pass unnoticed by mere protest.

The Grosvenor Gallery Installation.—We learn that this installation now gives great satisfaction ; but it is to be regretted that Mr. Ferranti intends relying upon one dynamo for supplying the current. Mr. Ferranti is a young man, and probably does not see the disadvantage of putting all his eggs in one basket ; he may, however, some day buy experience very dearly.

Steam and Steam Engines.—Mr. Andrew Jamieson, Principal and Professor of Engineering at the College of Science and Arts, Glasgow, has compiled a textbook On Steam and Steam-Engines, specially arranged for the use of Science and Art, City and Guilds of London Institute, and other Engineering Students.

NEW COMPANIES REGISTERED.

Automatic Electric Railway Signal Company, Limited.—Capital, £100,000 in £1 shares. Objects: To manufacture apparatus for railway signalling and articles of a similar nature or appertaining thereto, and particularly to acquire and work the letters patent, No. 74,105 dated November 2nd, 1886, entitled "An improved method of automatic electric signalling for railways and apparatus therefor." Signatories (with one share each), Frederick Levi, 3, George Yard, Lombard Street ; F. J. Vinall, 4, Portobello Terrace, Notting Hill Gate, W. ; J. R. Barry, Clapham Park ; H. E. Hardy, 28, South Castle Street, Liverpool ; Edwin Reeve, 13, Great Charlotte Street, Liverpool ; James Buchanan Graham Peters, 54, Church Street, Liverpool ; J. G. Gilbert, 47, Lime Street, Liverpool. The company being registered without articles of association, table A. of the Companies Act, 1862, will apply, in accordance with which the subscribers appoint the first directors and act as directors *ad interim*. The remuneration of the board will be determined by the company in general meeting. Registered office, Dashwood House, New Broad Street, E.C. Registered 1st inst. by Edward Walker, Dashwood House.

Manchester Electric Supply Company, Limited.—Capital, £10,000 in £10 shares. Objects: To create and produce electricity and to supply the same for lighting and other purposes. Signatories (with one share each), J. Thornton Chancellor, C.E., 31, Market Street, Manchester; W. H. Vaudrey, 9, St. James's Square, Manchester; *A. Bromley Holmes, and *J. C. Vaudrey, 1, Crosshall Street, Liverpool; *J. F. Albright, and *R. E. Bell Crompton, 11, Queen Victoria Street, E.C.; W. A. Ryle, Arc Works, Chelmsford. Directors' qualification, £100 in registered shares or stock. The first directors are the signatories denoted by an asterisk. Registered 3rd inst. by G. Maclaren, 22, Chancery Lane.

Union Electrical Power and Light Company, Limited.—Capital, £500,000 in £5 shares. Objects: To carry on the business of electrical engineers and contractors, and to supply electricity, electrical currents or force, for light, heat, motive power, telegraphic, telephonic, or other means of communication. Signatories (with 10 shares each), A. G. Miller, 21, Mincing Lane; W. T. Ansell (electrical engineer), 50, Old Broad Street; William Clark, 53, Chancery Lane; H. Percy Horne, 49, Gloucester Gardens, W.; John Pirie, 35, Eastcheap; H. Drake, Devon House, Forest Hill; J. A. Timmis, C.E., 2, Great George Street, S.W. The signatories are to elect the first directors and appoint their qualification. Subsequent directors are to be holders of 50 shares. Remuneration (exclusive of expenses) £1,500 per annum. Registered 6th inst. by Linklater & Co., 7, Walbrook.

OFFICIAL RETURNS OF ELECTRICAL COMPANIES.

E. T. Syndicate, Limited.—The registered office of this company is now situte at 19, Maldon Crescent, Kentish Town.

Loeb Chemical Electric Light Company, Limited.—An agreement dated 1st ult. (filed on the 5th ult.) between Leon Napoleon Loeb, of St. Michael's House, Church Alley, Basinghall Street, American merchant, and the company, provides for the allotment to the former of 3,000 fully-paid shares in the company. The offices of the company are now situate at 2, Holland Street, Oxford Street.

Primary Battery Company, Limited.—Under an agreement dated 1st inst. (filed 2nd inst.), this company will issue fully-paid shares in conformity with an agreement of 21st June, 1886, as follows:—W. Worby Beaumont, 134 shares; Charles Henry Walker Biggs, 136 shares; Rookes Evelyn Bell Crompton, 133 shares. The shares will be accepted in full satisfaction of the sum of £2,000 in shares, payable under the said agreement.

Standard Electric Light and Power Company, Limited.—The annual return of this company, made up to the 12th ult., was filed on the 1st inst. The nominal capital is £300,000 in £10 shares. 9,700 shares are issued as fully-paid, and upon seven others the full amount has been called, the total calls paid amounting to £6, and unpaid to £64. Registered office, 8, Great Queen Street West.

T. J. Howell, Limited (Manufacturers of carbon and electrical apparatus).—An agreement, dated 26th ult. and filed on the 1st inst., provides for the purchase from Mr. Thomas James Howell, of 72, Canterbury Road, Kilburn, of certain patented inventions for improvements in machinery and apparatus for cutting carbon and other substances, and also to purchase an engine, machinery, plant, &c., used by him in connection with the said invention. The purchase consideration is £150 in cash and £500 in fully-paid shares.

CITY NOTES.

West India and Panama Telegraph Company, Limited.—Holders of the six per cent. debentures of this company, maturing December 31st, are given the option, on or before the 28th inst., of extending the period of payment for five years from that date at 5 per cent. per annum. Debentures must be lodged with Messrs. Barclay, Bevan & Co., 54, Lombard Street, E.C., in order that the requisite endorsement may be made and new coupons attached. Holders who wish to take their principal money at the due date will receive the amount at Messrs. Barclay, Bevan & Co's. on and after December 31st.

Brazilian Submarine Telegraph Company, Limited.—The directors have declared an interim dividend of 3s. per share, or at the rate of 6 per cent. per annum, tax free, for the quarter ended September 30th payable on the 24th inst.

Spanish National Submarine Telegraph Company, Limited.—The numbers are published of 62 debentures of £100, amounting to £6,200, which have been drawn for payment at par on the 31st inst. at the National Bank of Scotland, Limited, 37, Nicholas Lane, Lombard Street, E.C.

Great Northern Telegraph Company, Limited.—The numbers are published of 50 debentures of 1881, which have been drawn for payment on January 1st, 1887, by Messrs. C. I. Hambro and Son, 70, Old Broad Street, E.C.

TRAFFIC RECEIPTS.

The West India and Panama Telegraph Company, Limited. The estimated receipts for the half-month ended the 30th November are £2,229, as compared with £2,165 in the corresponding period of 1885. The August receipts, estimated at £3,633, realised £3,679.

The Western and Brazilian Telegraph Company, Limited. The receipts for the week ending December 3rd were £3,688 after deducting the fifth of the gross receipts payable to the London Platino-Brazilian Telegraph Company, Limited.

The Great Northern Telegraph Company, Limited. The receipts for November. 1886, were £21,200; from January 1st to 30th November, 1886, £239,000; in the corresponding months, 1885, £264,440; and of 1884, £257,480.

The Direct Spanish Telegraph Company, Limited and reduced. The estimated receipts for the month of November were £1,860, against £2,032 in the corresponding period of last year.

The West Coast of America Telegraph Company, Limited. The gross earnings for the month ending November 30th, were £4,190.

The Brazilian Submarine Telegraph Company, Limited. The receipts for the week ending December 3rd were £4,515.

NEW PATENTS—1886.

15719. "Administering electric currents." J. Roots. Dated December 1.

15722. "Electric telegraphs." J. Y. Johnson. (Communicated by A. M. Rosebrugh.) Dated December 1.

15733. "Producing and utilising electricity." R. A. Parrish. Dated December 1. (*Complete.*)

15762. "Electro-magnetic accessories to maritime warfare." M. Immisch. Dated December 2.

15774. "Electrical switches and appliances." J. Probert. Dated December 2.

15776. "Compounds for covering insulated electric and other wires, and treatment of same." F. Walton. Dated December 2.

15822. "Securing the stems of telegraph wire insulators." J. D. Bishop. Dated December 3.

15831. "Depositing or obtaining metals by electrolysis." F. E. Elmore. Dated December 3.

15837. "Dynamo-electric machinery." J. A. Kingdon. Dated December 3.

15860. "Electro and electro-magnetic clothing." G. Green. Dated December 4.

15888. "Repairing the filaments of electric glow or incandescence lamps." A. M. Clark. (Communicated by C. Pauthonier.) Dated December 4.

15901. "Electric firing gear for rapid firing and other guns." A. Noble. Dated December 4.

15961. "Electric batteries." H. H. Lake. (Communicated by Count R. de Montgelas.) Dated December 6. (*Complete.*)

15964. "Electro-pneumatic and electro-pneumatic instantaneous stop mechanism for organs." F. Drexler, W. and E. Brauner. Dated December 6.

15980. "Electric apparatus for stopping steam and other engines." B. Taylor. Dated December 7.

15981. "Electric apparatus for stopping marine and other engines." B. Taylor. Dated December 7.

16005. "Communication of electric signals." J. Joyce and others. Dated December 7.

16036. "Apparatus for facilitating the delivery of letters, newspapers, &c." H. H. Lake. (Communicated by S. May.) Dated December 7.

16049. "Galvanic batteries." S. F. Walker. Dated December 8.

16050. "Dynamo-electric machines." S. F. Walker. Dated December 8.

16085. "Armatures for dynamo-electric machines." E. Jones Dated December 8.

ABSTRACTS OF PUBLISHED SPECIFICATIONS, 1885.

12001. "Improvements in filaments for electric glow lamps." J. SWINBURNE. Dated October 9. 8d. According to the invention a long filament may be made with a loop or loops, and the loop or loops held by supports, being short circuited in hydrocarbon, or similar gas if necessary. Thus, to make a 200 volt 16 candle-power lamp a filament, which would make two 100 volt 8 candle-power lamps, may be made with a double loop. The ends may be electrically joined to the leading-in wires, and the bottom of the loop, which will probably be between the leading-in wires, may be fastened to a third support. The part of the loop touching the support may be thickened by short circuiting so as not to be hot when the lamp is in use. By these means a lamp having the advantages of a multiple filament lamp may be made with one continuous filament instead of two, or several joined together. The short circuited part may be electro-plated to reduce its resistance, or to fix it to the support. Instead of short circuiting, a cement may be applied. The claims are 4 in number.

12084. "Improvements in dynamo-electric machines." J. HOPKINSON, F.R.S., and E. HOPKINSON. Dated October 10. 8d. Claim:—A multipolar dynamo machine in which the number of electro-magnets is less than the number of magnetic fields.

12096. "Improvements in appliances for regulating the current or electromotive force of electric currents, and the speed of motors." C. J. BOSANQUET, W. CAMERON, and W. A. TOMLINSON. Dated October 12. 8d. The object of the invention is to regulate the strength or electromotive force of electric currents. 1. By automatically varying the speed of the prime mover which gives motion to the dynamo-electric machine. 2. By automatically varying the strength of the field magnets, changing the position of the brushes, or otherwise altering the electrical condition of the dynamo. The inventors employ a solenoid, or other electrical equivalent, through the coils of which either a part or the whole of the current from the machine passes. The core acts upon gearing driven by the prime mover, or other convenient source, and upon variation of the current so regulates the flow of water, steam, or other fluid to or from a cylinder, afterwards called the auxiliary cylinder, the piston of which is connected to the throttle valve, expansion gear, or equivalent part of the prime mover. The claims are 15 in number.

12384. "Electrical submarine vessel." J. F. WADDINGTON. Dated October 17. 11d. Claims:—1. A submarine boat actuated and controlled by electrical power, constructed substantially as described, having a number of storage cells, accumulators, or secondary batteries carrying electricity, and one or more electro-dynamic machines, or electro motors, from which the propeller and other mechanism are driven. 2. In a submarine boat, propelled and controlled by electrical power, the combination with a pendulum of the horizontal rudders for maintaining the boat in a horizontal course, with the additional combination of an electro-dynamic machine, substantially as described. 3. In a submarine boat propelled by electrical power, the combination of the watertight compartments, the ballast tanks, and the inclined planes or rudders amidships, all substantially as and for the purposes described. 4. A submarine boat constructed and arranged, substantially as shown and described, always excepting the apparatus shown in the figs., and the torpedo-carrying and discharging apparatus.

12984. "An improved method of and apparatus for the working of metals and metalloids by the direct application of electric currents." N. DE BENARDOS, and S. OLSZEWSKI. Dated October 28. 1s. 3d. Relates to an improved method of, and apparatus for, the direct application of electric current for the following purposes:—1. The union of metals. 2. Their disunion or separation. 3. The formation of apertures in metals. 4. The union of metals in layers. The process which the inventors term electrc-hephaest consists of the formation of voltaic arcs when necessary. A voltaic arc is formed by the approach of carbon (or any other body serving the purpose) to the part of the metal to be operated upon: the carbon forms one pole and the metal forms the other pole of the circuit, in the majority of cases the carbon forms the positive pole. The claims are 8 in number.

13269. "Improvements in Telephonic Transmitters." G. L. ANDERS. Dated November 3. 8d. Claims: — 1. In a telephonic transmitter a body situated and suspended in a cavity so as to move therein under the action of deflected air waves in such manner that the air waves vary pressure between contacts carried respectively by the said body, or its moving attachments, and in the said cavity or otherwise by or connected with the body of the instrument, substantially as described. 2. In a telephonic transmitter a "collector" shaped as illustrated, situated in a deflector also shaped as illustrated, they respectively carrying contacts, the pressure between which is varied by the collected sound waves being conducted to the back of the collector, substantially as described. 3. In a telephonic transmitter a collector and a deflector, the former of a material of light specific gravity as compared to the latter, and so relatively shaped and arranged that the condensation of the air waves causes variation of pressure between contacts substantially as described. 4. The telephone transmitter, constructed or arranged substantially as described and illustrated in the drawings.

13744. "Apparatus for regulating or intercepting the current from dynamo-electric machines." E. J. HOUGHTON. Dated November 11. 8d. Has for its object either to vary the strength of electric current from a dynamo-electric machine, or to intercept such current altogether when the machine attains a certain speed. This is accomplished by causing the motion of the armature spindle of the machine to effect the raising of mercury or other conducting liquid in a vessel so as, when a certain speed is attained, to make a contact, and thus close an electric circuit comprising an electro magnet, the motion of whose armature causes a resistance to be introduced into the main circuit or shunt circuit of the machine, whereby the current will be diminished. Or the armature of the electro-magnet is made to break a contact whereby the main circuit or shunt circuit is entirely broken.

14337. "An improved construction of posts or supports for electrical conducting wires." C. D. ABEL. (Communicated from abroad by La Compagnie de Fives-Lille, of Paris.) Dated November 23. 8d. Claim:—The described improved construction of posts or supports for electrical conducting wires wherein four angle irons are arranged to form a tapering structure for the lower part of the post, these being secured together at intervals of their length at the required distances apart by means of distance pieces formed of plates or of angle irons, while the upper part of the post is formed either of four angle irons fixed closely together back to back, or of only two angle irons so arranged.

PROCEEDINGS OF SOCIETIES.

The Society of Telegraph-Engineers and Electricians.

AN ordinary general meeting of this society was held at the Institution of Civil Engineers, on Thursday, December 2nd, Prof. D. E. HUGHES, F.R.S., president, in the chair.

After the minutes of the previous meeting had been read and confirmed, the President invited further discussion upon Mr. Kapp's paper on the "Pre-determination of the Characteristics of Dynamos."

Prof. PERRY said he considered it the duty of a member at that period of the discussion to say very little unless it occurred to him that a point raised in the discussion required specially answering. Remarks which he was prepared to make at the last meeting had been very much taken out of his hands by the various previous speakers; but he considered it his duty to point out that Mr. Kapp's paper was exceptionally useful from the method described in it, by which the characteristic of a dynamo could be calculated without difficulty, from the beginning to the end, by the youngest member of the society. Others may have previously used a method somewhat similar, but their gratitude was due to Mr. Kapp as being the first to lay it clearly before the society. The most important point in the calculation was the determination of the leakage resistance, and the method was based on the assumption of that being known. Mr. Kapp found the leakage resistance by trial, and then fitted it to the characteristic; Dr. Hopkinson took a different method, and took his measurement from the leakage, not the leakage resistance; and in that he (Prof. Perry) thought that he was not quite right, because unless the leakage resistance could be calculated from the drawings, the characteristic could not be pre-determined. He could not agree with Prof. Forbes's calculation, and evidently that gentleman's judgment had been considerably used in the calculation of the leakage between the various parts of an electro-magnet, while he had left out an important leakage from one side to the other when the limbs were wide apart. He considered that it was more good fortune than the beauty of his method by which Prof. Forbes got an answer which agreed with Dr. Hopkinson's experiment. Dr. Hopkinson had objected to the use of the term electric analogy as being misleading. Prof. Ayrton and himself had given that point careful attention, and their experiments showed that up to about four-fifths of saturation the leakage resistance could be regarded as a constant to which the magnetisation would really be the analogue. As to the use of empirical formulæ, he certainly believed that empirical formulæ were of great use to people who made calculations connected with dynamo machines. Most of the laws he knew of had been worked out by simple algebraic formulæ, which had proved themselves to be not very far wrong. It was easy to work out algebraic rules by the graphical methods. Dr. Hopkinson's advice to young engineers to use the graphical methods he thought was misleading. A senior wrangler, of course, knew what he was doing when he used a geometrical method, but an ordinary electrical engineer would find far more advantage from the use of an empirical formula, even though it might be slightly wrong. He advised the use of what was called Frölich's formula, but which he himself had worked out some three years before Frölich had said anything about it. It had proved to be useful, and needed only one constant, which could be determined by Mr. Kapp's method. Anyone who expected more than Frölich's formula would give them in the pre-determination of a dynamo would be disappointed, and there were so many things that entered into the calculation, that probably the pre-determined characteristic would differ from the actual one more than Frölich's formula differed from what was the correct formula.

Mr. J. N. **Shoolbred** had not followed up the subject sufficiently of late to take part in the discussion.

Professor **Perry** reminded the meeting that in 1881 Mr. Shoolbred showed the characteristic of a dynamo which had a "drop" of the curve towards the end. Severe comment was passed on it at the time, but Dr. Hopkinson's paper showed that it was quite right that there should be that drop.

The **President** called upon Mr. Kapp to reply.

Mr. **Gisbert Kapp**, in reply, said that his paper had been misunderstood, perhaps from want of clearness, in regard to the question of the relative importance of the waste field at different degrees of magnetisation. An impression had been created that he denied the existence of leakage in a weak field, which was certainly not intended, but rather that leakage was of great importance near saturation and unimportant at low exciting powers. He was glad that Professor Ayrton had made the experiments he had described with different armatures between the poles of a horseshoe magnet, employing the law of parallel resistance, because it had converted him to the formula in the paper.

Professor **Ayrton** said that was not so, but it had made him see that the original formula was wrong because it neglected the leakage, and the law of parallel resistance would not hold good unless the leakage which existed was taken into account.

Mr. **Kapp** pointed out that the original formula was

$$z_1 = \frac{P}{R_a + R_a + R_{f.}}$$

Professor **Perry** remarked that there the resistances were in series.

Professor **Ayrton** said Mr. Kapp had given up that because he had introduced a leakage which the original formula did not provide for.

Mr. **Kapp**: Those experiments also showed that the lines of flow were the same in either of the two positions of the armature to the poles, and that was also proved by practice, for disc machines worked with lines which were in two planes, and they worked as well as other machines. The figures mentioned by Mr. Swinburne and Mr. Esson as to the relative size of the field magnet and armature coil he considered absurd. The machine described in Dr. Hopkinson's paper was said to contain 27 per cent. more iron in the magnet, and in the Manchester machine the proportion was 1 to 1·65; the Goolden and Trotter machine had equal quantities, and in the Kapp machine the excess in the field magnet was sometimes 50 per cent., according to the work required to be done by the current. Mr. Esson had asked how far he could go in reducing the iron in the field magnet or increasing it in the armature. Of course it would be easy to make cheap machines by simply increasing the armature and not the field, because the armature wasted a great percentage of the whole, and the material would not cost very much, but he (Mr. Kapp) considered that Mr. Esson had gone as far as it was advisable to go, and that the proportion of 3 : 4 was verging on the point when the leakage from the field magnet would be so great that the armature could not be saturated. Some encouraging things had been said by Mr. Crompton for those who were not mathematicians, but he also said that mathematicians had done very little to develop dynamo machines. It was hardly possible to draw a sharp division between mathematicians and non-mathematicians, and in fact developments were assisted by both; ideas flowed to and fro, and an improvement was brought to light and no one really knew how. But in the interest of science he would say that the increase of iron, which was really the basis of the whole development, had followed the employment of a formula which was not exactly right at the time, $E = \mu\, a^{\frac{2}{3}}\, b\, k$. It had no value now, but at the time, 1882, it was the nearest approach to correctness that was obtainable. It was the use of that formula which led Mr. Crompton to make that machine which contained what he had called a ridiculous amount of iron, and which had been useful in at once showing the ultimate effect instead of getting results step by step. If it was allowable to say anything complimentary upon a part of the discussion, he would congratulate Prof. Forbes on his very careful and painstaking working out of the resistance. He was not able to pronounce an opinion as to whether it was right or not, but Prof. Forbes had shown the possibility of working it out, and that was a very valuable point to those who had to work out calculations. He frequently did not work out his own calculations, because it would not pay to devote several hours for the purpose of obtaining a rough estimate; when a specific dynamo was required, then the calculations were usefully made. The proposed method of winding (fig. 1) suggested by Prof. Forbes had the great advantage of saving half the wire at present used, and would at the same time produce a more efficient machine, besides requiring much less labour in construction. Fig. 2 showed a somewhat similar arrangement which had been suggested some time ago, and was actually a double Forbes machine. As to the method of measuring the maximum induction referred to in Dr. Hopkinson's paper, he hoped that Mr. Crompton would make some experiments in that direction, because it was very interesting to know the maximum number of lines which could be got through a square inch of iron. A great deal had been said by Mr. Walker about leakage, about which he, like all others, had over-estimated the danger. Leakage seemed to be regarded by electricians as a great bugbear, and other things might get sacrificed in order to take it out. Prof. Forbes had stated 25 per cent. as the leakage, but that percentage did not apply to the whole weight of the machine, which was not increased in proportion to the leakage, as the supports of the machine remained unaltered. The perimeter of the exciting coil would have to be lengthened in order to get increased mass, and if the perimeter (fig. 3) were 28 inches without leakage and 30 inches with leakage, that would mean 7 per cent. extra wire, with an increase of 7 per cent. in the resistance of the coil, and of 7 per cent. greater current, which was very different to 25 per cent. more. In his introductory remarks Prof. Silvanus Thompson stated that the paper was not on the characteristic of a dynamo at all, but on the magnetisation of a dead piece of iron. That was true, but it was not intended that the paper should contain a treatise on dynamo construction, or to show the problems necessary to deduce one curve from another. Many disparaging remarks had been made upon the Frölich curve, but curiously enough the most severe condemnation came, unintentionally, from Prof. Thompson, who would rather uphold it. He had said that no man in his senses would work a dynamo at half-exciting power, but he had forgotten that circumstances were such sometimes as to compel it. If a shunt machine were used driven from a shaft in a factory at an unsteady speed, an automatic regulator had to be inserted to provide for the maximum output with a minimum speed, and at a maximum speed. Artificial resistance had to be inserted in the shunt magnet so as to reduce its exciting power, and in such a case it was possible that the work would be done with less than half the exciting power, in order to get the proper electromotive force and output at various speeds. On the question of units he (Mr. Kapp) felt very uncomfortable, and his heart sank within him when, at the previous meeting, one speaker after another called him all sorts of names. Professor Forbes said that he had committed a crime; Professor Thompson described the system as an inextricable mixture of centimetres, grammes, minutes, and inches. To that he protested because the system was not a mixture, and did not include the use of centimetres, grammes, or seconds; minutes were used because everybody was accustomed to speak of revolutions in a minute, and an engine driver could not be asked to run a machine at a decimal fraction of revolutions per second. Anyone unacquainted with French measure could work out his formula, and would understand it; they would know what was meant by 17 lines to the square inch, which was something a man could grasp; but to talk of 18,000 to the square centimetre was beyond an ordinary individual. Practical dynamo makers had not raised any objection to the system, and some had found it very convenient. Its translation to C.G.S. units was really not such a very difficult matter, and required only a little training; but it was no use of talking to workmen of grammes, centimetres, and seconds, they must have figures in the usual English measure, and therefore labour would be saved if the calculations were made by a system in which the figures were of reasonable magnitude, and directly applicable to the various shopwork purposes.

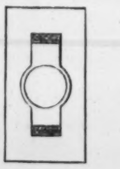


Fig. 1.

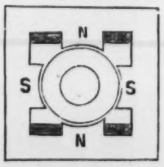


Fig. 2.

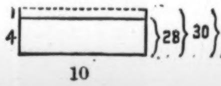


Fig. 3.

The **President**, in proposing a vote of thanks to Mr. Kapp, said he did not know which to admire most, the paper, the discussion, or the reply.

The following paper was read on "Some Experiments on Secondary Cells," by Mr. J. **Swinburne**, member :—

This paper is a very condensed account of a large number of experiments made in the spring of 1883.

About four years ago Mr. Norman Cookson, of the well-known firm of lead manufacturers in Newcastle, brought out a process for making lead in the form of fine fibre or hair. Mr. Cookson's method is this: The lead is melted in a pot which is raised some feet from the ground; from the melting-pot is a tube which leads down some 6 feet, and ends in a rose like that used on a garden watering-can. The fall tube is kept hot throughout its length, so that when the lead is melted in the pot it is not solidified in the pipe. The melted lead then flows through the fine holes in little jets, and these jets solidify in the air, and fall in a tangled mass like lead moss. Some care has to be taken to keep the lead in the pot and in the tube at the right temperature, but this is the only difficulty, and the whole cost of the lead hair is not more than two shillings per ton above that of pig lead.

Those who were working at secondary batteries this time four years ago will remember that most people had the idea that the great thing to be aimed at was a very large surface. Mr. Cookson's invention, therefore, seemed most valuable, and he set to work with the energy which is his characteristic, especially when working at something new. Mr. Cookson made up a dozen large cells, which he sent to Mr. Jameson, the inventor of the coke process, who was then working at an incandescent lamp. Some of the lead hair was made up into little cells, and tried in various ways by Professor Herschell, of Newcastle. Professor Herschell published some account of his work in *Nature*. Mr. Cookson also made arrangements with the writer to go into the question of secondary batteries. The theory that large surfaces of lead was necessary gave way when the question of local action was more fully studied, but after all it seems to be near the truth.

Some reason may be demanded for bringing before this society the account of experiments which were made so long ago. Many of them have been made again since, and many are of no use at all; but, on the other hand, there are a number which are still new, and the next best thing to knowing what to do is knowing what not to do. We made altogether more than 300 different cells; but to prevent this paper running to too great a length, only a few of them are described.

Cells with Hair Lead.

The first were Mr. Cookson's large cells. These had four plates; each plate was about 8 inches by 10 inches by 1 inch, and consisted of a sort of cage of sheet lead with holes in each side. The lead was joined by burning, no solder being used. The inside of the cage was filled with lead hair, a lead wire being arranged zigzag through it, and burnt to the cage. Each plate was sewn in flannel. A battery of 12 of these cells was sent to Mr. Jameson to be charged. They came back to the lead works without any particulars as to what had been done with them. We therefore coupled them up with a dynamo, and charged them in what appeared to be the opposite direction. They had 12 ampères through them for about seven hours a day for no less than five months, and even after three months gas was coming off the reduced plate only. The cells seem to have had enormous capacity, and must originally have been charged in the other direction. After three months the reduced plate gave off gas, but the peroxide plates went on charging for the whole five months. We did not try running them down to see what charge they really had, as other experiments which were going on at the same time led us to suppose that the local action would render them useless. Probably the surface of these plates was so large that the local action formed enough sulphate of lead during the night to utilise the current during the whole of the next day in oxidising it. At the end of the five months the flannel round the plates was not spoilt. This seems to show that it is not the acid that spoils the flannel in the Faure cells, but the oxidation due to the contact of peroxide of lead. Some experiments on organic substances with oxidising agents will be described presently.

The first difficulty to be overcome with the Cookson lead hair was making good electrical connection with the support. Various methods of soldering were tried, but the little wires of lead were melted off whenever it was tried to burn them to the back. Solder with a flux of caustic soda ran along the fibres too much. Various methods of connecting the fibres by pressure were tried. The material was woven into loose mats, and these were passed under large rollers. Every degree of density could be obtained in this way. Though the metal was clean, and appeared to stick together at first, it did not adhere as strongly as might have been expected. The chief fault of the lead hair seemed to be the vice of local action. In those days local action was not so well understood as now. The theory seems to be this: If lead and peroxide of lead are electrically connected, and any of the surface of the lead is exposed to the acid, that part of the surface is attacked, and a thin film of lead sulphate is formed which protects the surface from further corrosion. The lead is then in contact with the peroxide at some points, and with lead sulphate at other points, but is not touched by the acid anywhere. If the cell is charged further, the film of lead sulphate is oxidised into peroxide, so that the plate again consists of lead and peroxide of lead only. As the peroxide formed from a given quantity of lead sulphate occupies much less room, a small portion of the surface of the plate is again exposed, but is immediately coated with a film of peroxide; the result is that the whole surface of the plate is protected. The least movement seems to expose some of the surface of the lead to the acid. Mr. Crompton told me this summer that he found that cells were practically indestructible if not discharged too much, and this seems to be the grand secret of successful work with secondary batteries. Messrs. Drake and Gorham mentioned the same thing in their paper read at the British Association this autumn. Either the peroxide of lead is so porous that it never quite protects the plate, or it is disturbed by small bubbles formed in the coating; for if a current is passed continually in one direction a lead plate is eaten into, as may be seen in a water resistance with lead electrodes—the oxidised plate seemingly does go on forming. In the lead hair cells the surface exposed was so enormous that a very slight formation was enough to demand a very large supply of electrical energy, so that the cells seemed to run down as fast as they were charged. No doubt the fault was that the fibres of lead used were rather too fine; if we had used much thicker lead wire we should have probably made a very good battery. Several plates were tried with hair lead, red lead, litharge, &c., but our ideas as to the validity of Faure's patent were not quite what they are now, so comparatively little was done in that direction.

Secondary cells are, however, tedious things to experiment upon; it may take a year or so to see what a cell is going to do. The best method is to keep several sets of experiments going on at the same time.

For the sake of conciseness some of each class will be given, arranged in groups.

Quick-forming.

Cells were made with lead hair in a solution of sodium chloride: the anode was quickly attacked, but the coating was not adherent, and came off in clouds; black clouds, presumably of finely-divided lead, came off the other plate.

Lead hair and potassium bichromate: seemed to oxidise well.

Lead hair and potassium sulphate: no very marked result.

Amalgamated lead in dilute sulphuric acid: the peroxide formed had little stiction or power of adherence, and kept peeling off and exposing the bright amalgamated surface; this happened especially on reducing.

The object aimed at was to get an electrolyte which partly dissolved the plate; the idea being that an action like that of which advantage is taken in the manufacture of white lead might be used in the quick formation of battery plates.

Lead in solution of sodium-thiosulphate: thick black mud of lead sulphide formed.

Amalgams of lead and 10 per cent. and 5 per cent. of mercury: coating had no stiction.

Alloy of lead and zinc: this was not so easily attacked as one might expect.

Lead hair in solution sodium hydrate and sulphide: the solution got yellow, and deposited sulphur on the oxidised plate.

Lead in solution of ammonium chloride: was no better than the similar cell with sodium chloride. No doubt a little nitric acid was formed, but the cell was not a success.

Cells were tried with solutions of potassium fluoride: the plates were not formed well.

Lead in potassium sulphides: not much attacked; the action of the sulphide seemed uncertain, and is partly dependent on the amount of hydrate present.

Lead plates in solution of salt, with felt between: after reversal this gave good spongy lead, but a great deal of the peroxide was loose and detached.

Lead with various mixtures of sulphides and carbonates and nitrates: none of these gave deposits which would reduce well—they were all too loose.

Lead in sulphuric acid: just diluted enough to make it conduct; the anode was not much attacked.

Lead in a mixture of sulphuric and nitric acids: more quickly formed.

Lead in nitric acid alone: eaten through very quickly. The action of nitric acid on a lead plate is very peculiar. Most of the solutions already mentioned attacked the plate evenly and oxidised it gradually through, but nitric acid makes pits and round holes. As nitric acid seemed by far the best means of quick formation, several experiments were made with it. Plates were eaten wholly through with acid which was too strong to dissolve much nitrate; the acid was then siphoned off and replaced by a solution of sodium sulphate and reversed. There was difficulty in reducing the lead sulphate; it formed cakes which did not make good contact with the plate. The great objection to the various methods of forming above described is that the coatings produced have too little stiction to reduce well. When lead was the anode in nitric acid no peroxide was produced. Of course no peroxide is formed when the plate is in contact with sulphuric and hydrochloric acids, as peroxide of lead liberates chlorine in an acid solution, while chlorine precipitates lead peroxide from an alkaline solution of the lead salt.

The best solution we tried for forming plates was a mixture of dilute sulphuric and acetic acids: this solution made a fine and adherent coating which reduced well. One of the most obvious disadvantages of such solutions as dilute nitric acid is the difficulty of getting rid of the least traces of acid; of course, traces of such things as nitric or hydrochloric acid in a cell may be very destructive, or they may be quite harmless. Acetic acid can easily be driven off as vapour, and nitric acid might perhaps be reduced to ammonia and then volatilised.

Mr. Brush heats his plates to accelerate their formation; we did not try this.

Local Action.

To reduce the local action in the peroxide element we tried amalgamating the plates: this did not act. We tried to gild lead plates, but did not succeed; a gold sleeve-link seemed to act well as a support for a little peroxide plate, and it was hoped that gilding might preserve lead. We tried to protect lead by various sulphides. These experiments seem absurd; in fact, many of our experiments were rather wild; but the supposed method of protecting plates has recently been patented by no less able a chemist than the late Mr. Tribe. Lead was fused with various proportions of galena, and the resulting substances were tried as anodes. Galena itself is at once coated with lead sulphate when used as anode in dilute sulphuric acid.

Lead was also combined with arsenic by heating in glass tubes: this was very troublesome work, as the arsenic was apt to volatilise, and sometimes the tubes broke, and the laboratory had to be abandoned until the smell was gone.

Double sulphides of antimony and sulphur bases were tried, but were of no use. In our provisional protection applied for in 1883 we mention coating the plates with lead sulphide by means of thiocarbamide. This idea was taken from a receipt seen in a copy of the *Plumbers' Times and Paperhangers' Gazette*, or some such paper, which was sent me with an intimation that I had no business not to take in my trade journal. Thiocarbamide could not be bought, and was too troublesome to make, so this plan was not tried. The process is said to produce a beautiful polished adherent coating of lead sulphide on lead, or even on organic substances such as netting, and is of very considerable interest, and perhaps of commercial value.

Silver was tried as peroxide plate in various solutions. It behaved very much like lead, though it is not so easily attacked by sulphuric acid; peroxide of lead sticks to it well, but of course it is too expensive for commercial use. Silver might be used for connections. Most metals exposed to the action of the spray from secondary batteries are attacked, and make bad contacts, but silver may be laid across the top of a cell without tarnishing. Probably electro-plated copper would do as well. Very few experiments were tried with platinum because of the expense. Mr. Brush has patented plates made of an alloy of lead and platinum. Most likely it would take a very large proportion of platinum to protect a plate, as the alloys of platinum are easily oxidisable. No doubt Mr. Brush's invention is only waiting for the discovery of a platinum mine.

Local action may be a very serious evil in reduced plates, especially with strong acid. In some cases reduced plates in dilute sulphuric acid give off little bubbles of gas continuously for a couple of weeks. Spongy lead seems to have very nearly strong enough affinity for the electro-negative radicle of sulphuric acid to combine by evolving hydrogen, more especially if the acid is strong. It seems likely that traces of some metal even slightly negative to lead may start local action. Platinum and lead, for instance, decompose dilute acid at once; but perhaps traces of arsenic or antimony in the oxides from which the reduced coating has been made, or in the acid, may sometimes produce the same result. Peroxide of lead, on the other hand, is more stable, though when heated with strong sulphuric acid it seems to evolve some oxygen and turn lighter in colour.

Electro-gilded copper was attacked at once by sulphuric acid.

Carbon for Peroxide Plates.

The practice of making peroxide plates of carbon does not seem to be quite abandoned even yet. Carbon is more easily oxidised than is popularly supposed; in fact, Brodie's process for disintegrating graphite depends on the action of an oxidising agent. We tried some Faure plates with carbon in dilute sulphuric acid and in a solution of zinc sulphate. In both cases the carbon was attacked. After standing for some days the peroxide plates seemed quite good, and the peroxide appeared to stick well to the carbon and to form good coatings. On examination, however, it was found that the carbon under the peroxide was converted into a soft black pulp. Carbon was tried as anode in various solutions, such as sodium carbonate, sodium phosphate, phosphoric acid, dilute sulphuric acid, potassium fluoride, potassium sulphide, hydrochloric acid, potassium chromate, ferri-cyanide, ferro-cyanide, permanganate, borax, potassium tungstate, potassium hydrate, sodium chloride, &c. In all cases where oxygen would otherwise have to be evolved the carbon was attacked, but when a current could pass by evolving chlorine the carbon was not attacked. As peroxide of lead acts on a chloride in an acid solution, carbon is evidently useless for peroxide plates. It may do admirably for bleaching or evolving chlorine or making hypochlorites. The same conclusions were arrived at by Bartoli. Biscuit, or unglazed porcelain, impregnated with carbon deposited from hydrocarbon by heat, was tried: it split into small pieces. It is odd that none of the sufferers from primary battery disease have used this material for porous pots, as many of them have the idea that a carbon porous pot somehow reduces the resistance of the cell.

As no metals were available as indestructible supports for the oxidised plate in dilute sulphuric acid, and as carbon also appeared useless, the next thing was to try to make the supports of peroxide itself. Peroxide made by oxidising coatings made originally from litharge or red lead was not hard enough to make good supports; but the peroxide deposited by electrolysis of an alkaline solution of a lead salt was very much harder. The best way seemed to be to make a paste of litharge and caustic soda, and to attach it to the lead plate and make it the anode in a solution of caustic soda. When the whole of the litharge was oxidised the lead plate was removed. The resulting peroxide was very hard, and seemed quite impervious; when a bit was used as a plate in a cell, and the cell discharged, it ran down at once, the peroxide being covered by a very thin film of lead sulphate. The surface seemed to be the only part in contact with the acid. It would be a matter of great practical difficulty to make cells with peroxide supports commercially. It would be interesting to know how this form of peroxide compares with Mr. Fitzgerald's *lithanode* in point of hardness and durability. The peroxide from a solution of nitrate and tartrate of lead looks very dense and hard, but it comes in the form of scales resembling iodine. Before leaving the subject of lead plates some experiments on lead sulphate must be described. It was supposed at one time that lead sulphate could not be reduced in dilute acid. Sir William Thompson had made experiments with it, and had found it would not reduce. We made a cell with platinum plates and precipitated lead sulphate in dilute sulphuric acid; it was charged for five weeks, and at the end of that time the sulphate on one was completely oxidised, but on the other it was only reduced here and there in spots. A similar cell was then started with a little litharge mixed with the sulphate: the sulphate then reduced perfectly. This is a result of some importance. The reduction of sulphate seems to be purely a question of good contact. In many cells which gave very small outputs the reduced plates were found to be in fault. The slightest film of thoroughly-formed sulphate acts as a perfect insulator. It is a good plan to keep a small cell always ready with both plates fully charged; then, when a cell under test runs down, each plate is separately tried with a proof plate, and it is then found which of the plates has failed. The film of sulphate formed on a piece of lead reduces all right, but as sulphate of lead is very bulky its formation seems to cause buckling about and resulting bad contacts. To see how great the swelling due to the formation of sulphate of lead is, the specific gravities were taken, and the following are the resulting figures:—

100 volumes of lead form—

Peroxide of lead	160
Red Lead	148
Litharge	151
Lead sulphate	297

This shows that lead converted into sulphate swells into three times its original bulk, and that peroxide on becoming sulphate is doubled in volume; this at once shows why coatings tumble off plates. To see how much of the active material in a cell is really used, several plates were made up with weighed quantities of lead oxides. One of these was a little Sellon plate, made of a piece of a large plate filled with minium or litharge; others were Faure plates. After charging, the plates were short-circuited through copper voltameters. The maximum output was from 5 to 7 per cent. of that calculated.

Many attempts were made to make coatings that would stick well. Collodion was of no use; litharge and sugar did not make good coating; sodium silicate mixed with the litharge before applying was useless. Litharge and glycerine form a very useful cement known as engineers' cement. Though the coating was very easy to manage, there seemed to be no permanent advantage in using glycerine. This coating has been patented. In those days it was usual to wrap plates in flannel to keep the coating on. The flannel generally went to pieces very soon; it appeared, however, that this is not due to the action of the acid, but to oxidation through contact with the peroxide. Asbestos paper is too weak to be of any use. Cotton or linen is soon destroyed by acid, but resist strong alkali longer; while flannel resists acid, but is attacked by alkali. Pyroxylin is easily attacked by alkali, not easily by acid. Tribe proposed to use pyroxylin for supporting plates. Xylonite has also been tried for me more recently by Mr. Cathcart, then my assistant. It is much the same as celluloid, being made of pyroxylin and nitro-benzole, camphor, or same such solvent. This will stand being boiled in moderately strong sulphuric acid for a long time, and should be very useful in battery work. Flannel was soaked in collodion, with the idea that the fibres might thus be protected, but they were not. Flannel was also soaked in sodium silicate and attacked with sulphuric acid: it succumbed.

Strength of Acid.

It was usual to use acid of a strength of 1 to 10. This probably arises from that being the strength in vogue for Daniell batteries.

The strength of acid was also not considered, because the action of secondary batteries was for some unaccountable reason supposed to be due to the formation of litharge on both plates. I am afraid Dr. Lodge was much to blame for perpetuating this error. Another absurd theory was that the action is due to occluded hydrogen in the reduced plate. It has been said that the study of secondary batteries belongs to chemists, not to electricians; but it is strange that when chemists have to deal with electrolysis they seem to forget their chemistry, or to imagine that the laws of chemistry no longer hold good. As the action of the cell depends on the formation of lead sulphate, it is clearly an advantage to have as much acid as possible available in the coatings. If the coatings have only weak acid, it may be all absorbed when the cell is discharged a little, and the electromotive force will fall, and there will be a tendency to the formation of basic salts in the coatings; but, on the other hand, if the acid is made stronger, it may be decomposed without electrolysis, as when peroxide of lead evolves oxygen and forms lead sulphate, or as when spongy lead evolves hydrogen and forms lead sulphate. In the case of spongy lead there may or may not be electrolysis. If the acid is so strong that the lead decomposes it directly, there is no local action; but if there be some more electro-negative metal, such as, say, antimony, in contact with it to evolve the hydrogen, there is electrolysis. The best strength of acid was not determined by us, and it no doubt depends on the purity of the lead, and of all the compounds forming the coatings, and of the acid itself. It also depends on the way the cells are to be used. If the acid is strong, both oxygen and hydrogen will be given off slowly, even during several weeks. As the idea of using secondary batteries as magazines for storing energy for long periods is being given up, this slow decomposition is of little importance; but there is another point—that is, that sulphuric acid which is not very dilute separates into two strata of different specific gravities. Before leaving the subject of lead cells, it may be as well to mention that the troublesome spray that comes during charging may be prevented by floating paraffin on the top of the acid. The spray not only tarnishes, rusts, or destroys everything near, but is the cause of all sorts of ground leaks. The paraffin prevents the acid from creeping; in fact, it creeps itself, and acts as an insulator.

Alkaline Cells.

It is well known that iron is very electro-negative in an alkaline solution; but such solutions as that of caustic soda or potash are not available, because nearly all salts of lead are soluble in them. It was therefore attempted to make cells with iron supports in an alkaline solution of some salt whose acid radicle would not attack iron, and would precipitate lead salts. Iron in solutions of potassium cyanide, ferro-cyanide, and ferri-cyanide was attacked, the ferro-cyanide or yellow prussiate of potash plate was least eaten. Even such salts as sodium sulphate dissolve some lead sulphate. This property is important in connection with ordinary secondary batteries. A little sodium sulphate mixed with the acid may tend to make the sulphate of lead more easily reduced; as, when all the sulphate is reduced that is in contact with the support, hydrogen is evolved, and caustic soda is formed in the immediate neighbourhood of the plate, and can dissolve the sulphate, the lead being then precipitated as spongy lead. The spongy lead can thus make contact with the sulphate. Magnesium sulphate has been recommended as a solution, but it is difficult to see why. Zinc sulphate might be good.

Alkaline sulphides of course attack iron.

Iron plates with coatings of white lead in solutions of sodium carbonate; these oxidised and reduced very well, but the iron seemed to be slightly attacked. On testing the peroxide, traces of iron were found. Thinking the corrosion of the plate was perhaps due to impurities in the carbonate, such as sulphate, experiments were tried with the purified salts. The iron seemed to be in a sort of unstable state. Sometimes it would remain quite clear and bright in contact with the peroxide, and with bubbles of oxygen evolving from its surface; but suddenly a green spot would appear, due no doubt to the formation of carbonate of iron, and this spot would extend and cover the whole plate. The best results were got with bicarbonate of soda.

Nickel was tried in the same solutions: it behaved in the same way, though it was not quite so easily attacked. The carbonate was lighter in colour, being apple green.

Iron plates with borax solution: green discoloration.

Iron plate with caustic, potash, and tannin: iron eaten.

Some cells were tried with iron plates and ammonia; but as it is probable that nitric acid would soon be formed in them they were abandoned. The alkaline cells gave 1·7 volt. The measurements were taken roughly. A calibrated tangent galvanometer was used as a voltmeter; for measuring currents a low resistance was made up consisting of a lot of wires put in parallel, their resistance having been measured in series.

Ammonia sometimes gave a brown deposit with iron plates.

As it seemed hopeless to get iron to stand without being attacked, various methods of protecting it were tried. Iron gauze was coated with peroxide by making it the anode in a solution of litharge in caustic. When this solution is electrolised clouds of litharge are evolved close to the plate. This is very curious, for if the solution is plumbite of lead the electro-negative radicle would be $Pb\,O_2$, not $Pb\,O$: such a salt being presumably $Na_2\,Pb\,O_2$. Peroxide of lead deposited from solution of litharge in caustic is too dense to be used as an active coating; it was proposed to use it to protect the iron, and to have then applied a coat of porous peroxide such as is used in acid cells. The peroxide was never satisfactory. To make up for the imperviousness of the peroxide, red lead and water were rubbed into the pile of velvet; the velvet was placed with its face against the iron plate, and the coating was oxidised in an alkaline solution. The velvet was then dissolved out by strong alkali, so as to leave a coating with a very large surface. This plate, however, had very small capacity. Electro-gilding the iron was then resorted to. It is a little difficult to gild iron, as the gold does not stick well. After each coat of gold the iron was heated to make the gold sink in. The gilded plates did not answer well. The Bower-Barff process for protecting iron from rust was tried, by getting an ornamental railing top and making it the anode in a cell. The black oxide did not prove to be a good enough protection. The strange thing about the corrosion of iron in alkaline solutions is that it does not take place if there is no coating. A piece of sheet iron may be used as anode in the solution of carbonate or bicarbonate of soda without being the least corroded; but if a coating of, say, white lead is applied, green spots appear at once, but only under the white lead; the back of the plate remains quite clear. Oddly enough, sheet tin is not easily attacked by an alkaline solution. Sometimes it turns black, or the surface, which consists of an alloy composed chiefly of tin, peels off in black scales. Sheet tin behaved much as iron and nickel; that is to say, it behaved very well till a coating was put on, and then it was corroded. There is a very curious alloy of iron and tin. If iron and tin are melted together, the resulting alloy separates into two portions; one is approximately $Fe\,Sn$, and the other consists chiefly of tin, and has a low melting point. The alloy $Fe\,Sn$ solidifies at a red heat. It was too unmanageable to be of much use for batteries, and it was no better than sheet tin; but it was so hard that a straw-hardened cold chisel even would not cut it, but broke in pieces, while a softer chisel turned up at the edge. This alloy might be useful in commerce. The writer has since tried to make more of this alloy for some experiments on persistent magnetism, but has never succeeded in making it so hard again.

Iron without a coating is not attacked in such solutions as potassium bichromate, or permanganate. At first sight this seems strange, but it must be remembered that such salts owe their corrosive properties, especially when acting on organic bodies, not to the strength of their acid radicles, but to the electro-positiveness of chromium and manganese, which makes them combine energetically with an acid radicle to form chromium or manganese salts. Thus potassium bichromate or chromic acid in the presence of sulphuric acid is a very powerful oxidising agent, but if there is no acid present to form a chromium salt it is no longer energetic. Iron in alkaline solutions is very convenient for adjustable water resistances.

We worked at iron cells with some tenacity, because we seemed to be very near sucesss; and if we could make a peroxide plate with iron without local action, the negative might be of zinc, as this combination gives a high electromotive force.

Cells with Zinc.

Evidently cells with zinc could not be used in most acid solutions, as so many of its salts are soluble. Secondary batteries with zinc plates have often been brought out; but as the zinc dissolved on discharging is not deposited on the same part of the plate on charging, these cells cannot well be used very often. M. Reynier has lately worked at cells with zinc in sulphuric acid, and Planté peroxide plates. He does not say how he proposes to get over the difficulty of the zinc being deposited in the wrong place. He says that the deposited zinc is so pure that there is very little local action. His cells give 2·37 volts.

We tried plates with reduced zinc coatings in alkaline solutions that do not dissolve zinc, such as sodium carbonate and sodium bicarbonate. The coatings were made of oxide or carbonate of zinc. The chief trouble was the proper reduction of the zinc. These salts of zinc behave very much like lead sulphate—that is to say, they are very bulky—and the coatings form hard white cakes which are not in good contact with the support. When the zinc is eventually reduced it is very soft and loose. Very likely we made a mistake in reducing coatings of oxide or carbonate of zinc, instead of forming the coating out of the solid plate by attacking it when used as anode. The object aimed at was the use of iron for the support of lead peroxide in the other element; but as we did not get iron to work satisfactorily, we did not do very much with the zinc.

Primary Cells.

A few experiments were made, but they are not worth recording. Lately, however, the writer saw a note in the *Electrician* to the effect that a French *savant* had used agar-agar jelly in a Leclanché cell. It seemed possible that the use of this might avoid the necessity for a porous pot in a two-fluid cell, the idea being that to make up a cell one might take a zinc plate, place on it a wad of zinc sulphate jelly, place on that a wad of copper sulphate jelly, and cover it with a copper plate. Zinc and copper jellies are easily made, but the drawback is the rapid diffusion of the copper salt. Some cells were made with zinc filings suspended in the zinc jelly, so that any wandering copper salt might be caught before it reached the zinc plate. As rapid diffusion is always the result of a low-resistance porous cell, it seems useless to try to make a low-resistance two-fluid cell unless some colloïd oxidising agent can be found. Some of the solutions of iron were found by Graham to be colloïdal; perhaps something might be done with them.

A bichromate jelly cell was tried, but it was also a failure. The same thing was noticed as in the case of flannel and cotton. Bichromate jelly with no acid keeps for any length of time; and sulphuric acid jelly can also be made; but the jelly dissolves at once if both acid and bichromate are present. The same thing happens with potassium permanganate.

Agar-agar is a fucus or sea-weed. It has, if the writer is not mistaken, the same composition as starch. It has a very high gelatinising power—about ten times that of gelatine. It is probably used for sizing paper or calico, or for cooking. Mr. Stanford, of Glasgow, is an authority on the uses of sea-weeds.

Gelatine was tried, but it was liable to go bad, and was at once attacked by oxidising agents.

Probably gelatinous silica may do, but the writer has not yet made enough experiments to say. A low-resistance bichromate cell in which the bichromate had not access to the zinc would be very useful where a large power is occasionally required, as in the laboratory.

Miscellaneous.

While various cells were being charged or discharged there were often odd quarters of hours to spare. These were spent in trying different experiments not connected directly with secondary cell.

White Lead.

It was attempted to make white lead electrolytically. The present method of making white lead, which is felicitously termed the "Dutch process," is slow and barbarous, and exceedingly unhealthy. The women who are continually among the white lead absorb the lead through their skins, or perhaps swallow it little by little, and are apt to suffer from lead poisoning. Messrs. Cookson & Co. have probably the best sanitary regulations and arrangements in the world; but even then the Dutch process is very dangerous.

To make white lead electrolytically, plates of lead were made anodes in solutions of carbonate or bicarbonate of soda, with very small currents. In many cases white deposits were obtained, but in no case was any quantity obtained. If the current was increased the plates were soon coated with a brown compound. To imitate the action of the basic acetate a little acetic acid was added to some of the solutions. In some cases a very curious phenomenon was seen. Long white columns like small candle drippings started about the middle of the plate, and grew down to the bottom of the beaker. The plates were about three inches from the bottom.

Experiments were tried with lead plates and solutions of salt with a view of making white oxychloride of lead. The plates were of course easily attacked, but if the current was very small the coating formed very slowly, and appeared crystalline, and if the current was increased the coating turned brown.

Sodium Chlorate.

Potassium chlorate is very largely used for making English matches, and in dyeing; it is probably used instead of sodium chlorate because it can easily be separated from chloride by crystallisation. To make sodium chlorate, solution of salt was electrolysed. This gives off chlorine at the anode, and various salts, such as sodium hypochlorite, are formed. If sodium hypochlorite is boiled it gives chlorate and chloride. We prepared a mixture of sodium chloride and chlorate, but the percentage of chlorate was too small for the process to be valuable.

Aniline Dyes.

There may be a large field for the application of electrolysis in the aniline industry.

A cell was tried with aniline, but it would not conduct.

A cell was tried with phenol, but it would not conduct. Potassium hydrate was therefore dissolved in the phenol to make it conduct. A black compound was formed at the anode.

These last experiments are not brought forward as of any value, but they are instances of applications of the dynamo to very different industries. Now that we have the dynamo as a commercial machine, we seem to be resting content with one very small use for it. We use it almost entirely for the electric light. Though it is quite well understood that power can easily be transmitted electrically, the use of motors can hardly be said to be pushed at all. Engineers have only to be shown motors at work to see what beautiful, smooth, and silent-running things they are, and they will be applied in thousands of instances. The dynamo is now being introduced for the treatment of argentiferous copper; but this is a comparatively small industry. The electro-plating fraternity are a very peculiar people. Though constantly using it they seem to know as little about electricity as medical men. Before electricians can meet them on common ground they must give up talking of the strength of the quantity of current from seventeen Smee cells.

But above all these uses the electrical engineer can supply the chemist with a most efficient and convenient oxidising or reducing agent; unfortunately, however, the electrical engineer does not know what the chemist wants, and the chemist does not know what the electrician can give him.

Every week more young men begin studying to qualify as electrical engineers. Like pins, it is unknown what becomes of them. Would it not pay some of those who are sharp and inventive to take up the study of electro-metallurgy systematically, and to explore that almost untrodden field of the application of the dynamo?

The PRESIDENT said it was too late to commence the discussion on Mr. Swinburne's paper that evening. The next being the annual meeting, would take place on December 9th.

The meeting then adjourned.

CORRESPONDENCE.

The Management of Accumulators.

I feel as grateful to you for pointing out the failings of my pamphlet as for your praise. It is right for me to point out one or two instances of error into which you have fallen, some, it is true, from no fault of your own. The copy sent for your perusal was an early one, and without the preface, which counteracts the bluntness of the "Introduction." The primitive diagram will eventually give place to a proper one, and a photograph of the accumulator-house described, when the price will be one shilling. These are not yet ready, and publication would have been delayed, but for some special reasons with which I need not trouble you. The words used, "formed lead plates," are generally understood the right way as "unpasted ones." I assumed that there would be two classes of readers, one well acquainted with cells, and one who only attend them, so to make every point clear to both would entail a large volume, which would rarely be referred to. This accounts for the reason why the manipulative details only are most explicit. You ask why do I not give the *cause* for bad sulphating? It seems to me that it is already there, by stating that the cells should never be very much discharged. In future copies an appendix is being added, and should the public honour me by demanding a second edition, much new matter will be added, for each day new facts are found, and other chemical theories will be given. You appear also to have fallen into a misunderstanding regarding what is stated about the possibility of an indefinitely prolonged charging. If the current is continually made smaller as the material on the plates is reduced, the series is an infinite one, and therefore saturation is never reached. This is only looking at the question from a mathematical point of view. I know well many errors have been made which in time I hope to correct, yet the main object in view remains intact, namely, my firm belief that the rules given will much assist to keeping an accumulator in good order over many years.

David Salomons.

December 6th, 1886.

[In reference to the first portion of Sir David Salomons' letter, we have only to say that the pamphlet which he now states to have been incomplete came to us marked "For review if desired," in Sir David's own handwriting.—EDS. ELEC. REV.]

Clark's Standard Cell.

In your promised article on Clark's Standard Cell, can you kindly give the proper proportions for the ingredients of the "paste" which receives the zinc?

There are no quantities given in any of the published descriptions I have met with for the zinc sulphate and mercurous sulphate; and it is, perhaps, reasonable to assume that the E.M.F. of the cell may depend to some extent on the respective proportions, just as the s.g. of the solutions for the Daniell cell influences the E.M.F.

Dr. Fleming, in his lectures to electrical artisans, prescribes the addition of zinc carbonate; but, like other writers, gives no proportion for any of the ingredients.

Ajax.

[Probably the writer of the article will, if necessary, reply to "Ajax" in our next.—EDS. ELEC. REV.]

Tramway Gradients.

Some time since you asked for information as to places where tramways are worked over gradients so great as 1 in 17. I recently had an opportunity of examining the ordnance survey maps of Plymouth and Devonport, and find that on the tramways between these towns the well-known Devonport Hill has a gradient of 1 in 14, the hill being at the start 1 in 50, and in the middle 1 in 20. Four horses are habitually used to take the cars up this hill.

On another line laid in Plymouth and intended to be worked by steam, but now dormant, the company being in a state of transition, has two hills—one varies from 1 in 38 to 1 in 16, and the other from 1 in 31 to 1 in 9·4.

Your last week's article reminds me that this may now be interesting.

F. Tremain, A.S.T.E.

December 7th, 1886.

"A Wild Scheme."

In your issue of the December 3rd you reproduce an article from the *Financial News* on the subject of the proposed Atlantic cable *viâ* Lisbon and the Azores. In a foot-note appended to this article you justly point out that the difficulties connected with this scheme arise from a financial point of view, and not through physical impediments.

In support of your argument I would call attention to the cables laid to and between the islands forming the Canary, and the Cape Verde groups. All these islands are of the most pronounced volcanic character, yet the cables referred to have not only been successfully laid, but have lasted remarkably well. I cite these islands as instances, for they are directly comparable with the formation of the Azores, and with the characteristics of the surrounding ocean bed.

The author of the article in question draws a terrific picture of the bottom in the neighbourhood of the

Azores: precipices from hundreds to thousands of fathoms in depth, series of huge sharp-pointed rocks, submarine valleys and ridges, volcanic mountains, and submarine mud and other volcanoes, do not suggest the best bottom for a cable to rest on; but these difficulties have been encountered before, and have been successfully overcome. In the case in point they have been grossly exaggerated.

The author appears to suggest that the cable *must* be laid so as to hang suspended from ridge to ridge (as if the mountain tops were to be made use of as submarine telegraph poles), and his remark that "scientific men and experienced naval officers" have come to the conclusion that no cable can be manufactured strong enough to bear the strain of such suspension, should be of considerable interest to submarine cable engineers, introducing a novel feature in their work, for their aim has been hitherto, I believe, to carefully avoid any such operation as is here suggested.

A very great interest in submarine telegraphy must be my excuse for encroaching upon your space to such a length.

X. X.

Administration and Working of the British Telegraph System.

I am induced by your mention of the fact that 1887 is the jubilee year of the invention of the practical electric telegraph, to ask if the time has not arrived for a searching enquiry into the failure of the postal telegraph department, both financially and from an administrative point of view.

As to the financial question I have only to draw attention to the long refusal to the public of the sixpenny telegram on the false assumption that it would not pay, and to the eccentricities of finance by which the expenses of the postal and telegraph branches have been so proportional as to make the latter appear a paying concern, whilst the former is in a supposed state of bankruptcy.

In the matter of administration, the chronic state of discontent mentioned in the resolution of the clerks at Liverpool would be enough, even without the glaring want of efficiency as to errors and delays, which you have frequently drawn attention to, as regards the metropolis. The administrative failure is self-evident to the public, but not more so than the financial juggling, if they care to examine the estimates. For many years it was manifest from these that the proportion of expense charged to the telegraph department, as compared with the postal branch (mostly two-third telegraphs one-third postal) was unjust, as the staff and salaries opposite these proportions would at once show. This in fact is admitted, for in recent years the proportions have assumed a more varied character, such as eleven-sixteenths and five-sixteenths, and so on. A matter not so well known to the public is the manner in which that pet idea, the parcels post, is nursed, all parcels sent by post for the telegraph branch being stamped, and therefore paid for; whilst telegrams for the parcels post are transmitted free of charge.

It is easily understood that part of postmasters' salaries should be debited to the telegraph account; but why their chief clerks who in the presence of a telegraph superintendent do no telegraph work should be partly paid from that department's funds is somewhat more mysterious.

Again, where this proportionate arrangement obtains and mails are landed or dispatched, the postal officer, who does the duty, receives half a guinea or a guinea allowance, and a due proportion of this is religiously charged to the unfortunate telegraph account.

Even more ludicrous instances have been published of this convenient proportionate finance.

Another thoroughly unpractical thing was that admitted failure, the amalgamation of the staffs in large offices, and this administrative blunder has a good deal of inefficiency to answer for.

It is not necessary to remark on this matter of inefficiency further than to indicate what in the writer's opinion is the cause thereof. It is believed to be largely due to the administration of the telegraphs by postal officials, devoid of all telegraphic knowledge and the inventors of unworkable rules. These, too, have been administered with Spartan severity, until the staff are drilled into a rigid adherence to the letters of them, instead of observing their spirit; and are thus encouraged to make no use of their intelligence.

To the employment at branch offices of clerks, who are led to consider their telegraph work of quite minor importance to their postal duties, forgetting that they are, in telegraphing, admitted as it were into the merchant's office, whilst in dealing with sealed communications, they may be looked upon as in his messenger's lobby.

To the supervision being performed by old and valued servants, many of whom, however, whilst well adapted to clerical work, are unfitted for superintending the work on sounders they cannot read, and apparatus beyond their comprehension. They are men of the old school, and have done good and faithful service for 20 to 30 years, but are not judiciously employed.

I have said that the use of one's intelligence is not encouraged. I say more, that knowledge is absolutely at a discount, for if you know a little, you soon find that in the opinion of your superiors you know too much. I have been for many years a student of technology, have the highest honours in my own subjects, and some of the associated ones, and have no complaint myself to make of want of recognition, but I do complain, and believe it to be a serious defect, that in these days of technology little or no encouragement is given to its study in the telegraph service of this country. No work is well done, or system perfected, unless those engaged in its evolution are enthusiasts and diligent. I therefore submit that for the telegraph department to be a success financially, and to be administered in the best interests of the public, those who control it must be telegraph men with an enthusiasm for their vocation and possessed of a keen desire to engage in friendly rivalry with those who control the kindred departments. Such an one should be the secretary for telegraphs, and for his immediate staff he should have those who could qualify for the duties from his own department. Men intimate with every detail of telegraph routine, although not perhaps the rapid manipulators they once were, or acquainted with the elaborations of modern science. Allowances should be made for testing duties, as an encouragement to those who acquire technical skill. Two or three hundred allowances of, say five shillings a week, would have a wonderfully energising effect and raise the intelligence of the staff. The latter's status should be elevated as much as possible, and an *esprit d'corps*, and sense of personal honour encouraged in the accuracy, speed, and general success of their department.

At present absolutely the only encouragement to scientific study and self-culture in the telegraph department, is the prospect of appointment in the engineering branch, and to the credit of the universally respected heads of that department, be it said that they appear to be possessed with only one desire, and that to select the best from the almost bewildering number of applicants they get for a very few appointments, perhaps on an average two or three a year.

Let such men control the telegraph system of this country, surrounding themselves with telegraph men, and working on commercial principles, and I, as one having studied the question from inside the department for 10 years, have no fear for the result, either as to the efficiency of services rendered the public, or the contentment and good work of the employees.

Since writing the above I hear that evidence is to be submitted to the Royal Commission on the Civil Service in writing only and through heads of departments. Such a method will lead to a fiasco, as one of the pretty ways of departmental chiefs is the indulgence in reprisals.

Telegraphist.

[illegible]

Lighthouse, Ship Lighting, Mining, &c.

Lamps, suitable for Naval and Military purposes; Incandescent Lamps for Yachts or Boating.

[illegible]

Magnetos, S.H. [illegible] ments, &c., &c.

LIST OF [illegible]

Electro-magnets

Ayrton & Perry

Incandescent [illegible]

[illegible]

Engineering and Electrical Work of all kinds carried out. Estimates and Specifications for Electric Lighting free of cost.

ELECTRIC LIGHT LEADS, GUTTA-PERCHA, INDIA-RUBBER COMPOUND BRAIDED COTTON, SILK-COVERED WIRES.

SPECIAL WIRES FOR DYNAMO MACHINES

PHILLIPS BROS.,
ELECTRICAL WIRE MANUFACTURERS,
THE LEA TELEGRAPH WORKS, HACKNEY WICK,
LONDON,
FORMERLY OF
MACINTOSH LANE, HOMERTON.

ESTABLISHED 1870.

SPECIAL WIRES FOR INCANDESCENT LAMPS

GERMAN SILVER WIRES FOR HIGH RESISTANCES, FLEXIBLE CORDS, TELEPHONE WIRES, &c., &c. MULTIPLE, AERIAL, AND SUBTERRANEAN CABLE WIRES TO ANY SPECIFICATION.

[illegible] GUTTA-PERCHA & TELEGRAPH
WORKS COMPANY, LIMITED.

Offices and Warehouses: 106 & 100, CANNON STREET, LONDON, E.C.
Works: Silvertown, Essex; Persan-Beaumont, France.

TELEGRAPH ENGINEERS AND MANUFACTURERS

CABLES.—Submarine, Subterranean, and Aerial.
WIRES.—India-Rubber and Gutta-Percha [illegible]
[illegible]
[illegible] Carbon Plates, &c.
[illegible]—[illegible], Portable, [illegible], &c.

MANUFACTURERS of the most Improved Apparatus for RAILWAY BLOCK SIGNALLING.
[illegible] REPEATERS, "LIGHT" INDICATORS, AND WALKER'S "PASSENGER AND GUARD" COMMUNICATOR.
TELEGRAPH STORES AND APPARATUS OF EVERY DESCRIPTION.

TORPEDO APPARATUS.

THE INDIA-RUBBER, GUTTA-PERCHA, AND TELEGRAPH WORKS COMPANY (Limited) are Patentees and Manufacturers of a Complete System of Torpedoes for Harbour and Coast Defence,

AND OF THE

SILVERTOWN PATENT FIRING BATTERY.

A Constant Battery for Mining and Blasting Purposes.

CONTRACTS ENTERED INTO for the SUPPLY, CONSTRUCTION, and MAINTENANCE of TELEGRAPH LINES.

MANUFACTURERS OF

VULCANISED INDIA RUBBER.

VALVES, SHEET, BUFFERS, SPRINGS, WASHERS, WHEEL TYRES, CORD TUBING, AND DOOR AND CARRIAGE MATS.

INDIA RUBBER AND CANVAS SUCTION AND DELIVERY HOSE.

INDIA RUBBER and CANVAS STEAM PACKING—ROUND, SQUARE, and SHEET.

INDIA RUBBER MACHINE DRIVING BANDS.

WATERPROOF GARMENTS AND FABRICS:

Coats, Capes, Leggings, Hats, Helmets, Knee Wrappers, Diving Dresses, Sheeting for Hospitals, Water and Air Proof Beds, Pillows, Cushions, Bottles, Baths, Life Belts, Gas Bags.

EBONITE.

Not affected by Vinegar or Hydrochloric or Acetic Acid.

Pumps. Photographic Articles.	Speaking Tubes, Mouthpieces. Battery Cells.	Sheet and Rod. Surgical Appliances.

GUTTA-PERCHA.

Tubing, Belting, Buckets, Bosses for Flax Spinning, &c.

Works: SILVERTOWN, ESSEX, LONDON, E.; PERSAN-BEAUMONT, FRANCE.
London Office—106, CANNON STREET, E.C.
Warehouse—100, CANNON STREET, E.C.

BRANCH WAREHOUSES:

BOOTLE	70, Regent Road.
LIVERPOOL	18, Castle Street.
GLASGOW	20, Dixon Street.
BRADFORD, YORKSHIRE	36, Kirkgate.
SHEFFIELD	[illegible], High Street.
PORTSMOUTH	42, High Street.
BELFAST	58, High Street.
DUBLIN	15, St. Andrew Street.
BRISTOL	2, Clare Street.
NEWPORT, MON.	62, Dock Street.
CARDIFF	Pierhead Chambers, Bute Docks.
NEWCASTLE-ON-TYNE	6, Neville Street.
NORTH SHIELDS	Borough Road.
BIRMINGHAM	[illegible] Buildings, Corporation Street.
MANCHESTER	1, Fountain Street.
SWANSEA	23, Castle Street.
LEEDS	9, Trinity Street.